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Environmental Assessment Midcourse Space Experiment (MSX)

Environmental Assessment

Midcourse Space Experiment (MSX)

Strategic Defense Initiative Organization

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Responsible Agency:	Strategic Defense Initiative Organization
Proposed Action:	To develop, launch, and operate the Midcourse Space Experiment (MSX) spacecraft and to conduct a target program.
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Designation:	Environmental Assessment

Abstract:

The Strategic Defense Initiative Organization (SDIO) is proposing to operate the MSX spacecraft to gather information related to the following objectives: demonstration of midcourse sensor functions; collection of midcourse target and background data; integration of critical sensor technologies; and demonstration of surveillance from space. The data gathered will be used to design midcourse sensors.

The proposed action is to develop, launch, and operate the MSX spacecraft and to conduct a target program. Activities required to support this program include: 1) fabrication, assembly, and testing of the experiments at Utah State University/Space Dynamics Laboratory (USU/SDL), Johns Hopkins University/Applied Physics Laboratory (JHU/APL), and Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL); and 2) the launch and subsequent operation of the MSX spacecraft. This action will use existing facilities at USU/SDL, JHU/APL, and MIT/LL.

Availability: August 1992

Finding of No Significant Impact

Finding of No Significant Impact
Strategic Defense Initiative Organization
U.S. Department of Defense

Agency

U.S. Department of Defense
Strategic Defense Initiative Organization (SDIO)

Action

To develop, launch, and operate the Midcourse Space Experiment (MSX) spacecraft and to conduct a target program.

Background

Pursuant to Council on Environmental Quality Regulations (40 CFR 1500-1508) for implementing the procedural provisions of the National Environmental Policy Act (42 U.S.C. 4321 et. seq.), and the U.S. Department of Defense (DOD) Directive 6050.1, the Strategic Defense Initiative Organization (SDIO) has conducted an assessment of the potential environmental consequences of the development and subsequent operation of the MSX spacecraft and other related activities.

The Strategic Defense Initiative Organization is proposing to operate the MSX spacecraft to gather information related to the following objectives: demonstration of infrared and visible midcourse sensor functions; collection of multi-spectral midcourse target and background data; integration of critical sensor technologies; and demonstration of surveillance from space. These purposes will be accomplished through the use of the Space Infrared Imaging Telescope (SPIRIT III) and other instrumentation that will be launched on the MSX spacecraft on a Delta II booster from Vandenberg Air Force Base (AFB) into a polar orbit. MSX will observe a variety of targets, both dedicated and nondedicated. In addition to the dedicated targets, the MSX program will involve targets not driven by, or attributable to, MSX.

Fabrication, assembly, and testing activities for the experiments to be contained on the MSX spacecraft will be conducted at Utah State University/Space Dynamics Laboratory (USU/SDL), Johns Hopkins University/Applied Physics Laboratory (JHU/APL), and Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL). The proposed activities will be conducted in existing facilities and will be within the scope of activities routinely conducted at those facilities.

Integration and testing activities for the spacecraft will occur at JHU/APL and the National Aeronautics and Space Administration (NASA)/Goddard Space Flight Center (GSFC). Following these activities the spacecraft will be purged of any leftover fluids and shipped via C-5A military cargo aircraft to Vandenberg AFB, where it will be launched into a polar orbit on a Delta II rocket. The preflight and flight activities required for the launch will be conducted at Vandenberg AFB in existing facilities developed specifically for such activities.

Alternatives considered include no action, the use of other launch locations, and the use of other launch vehicles. The no action alternative was rejected because if the action did not occur, the actual flight test data that is expected to result from the experiments would not be available for the continued development of space-based sensors. The mission requirements for midcourse sensors development would not be met. Vandenberg AFB was selected as the launch location because it is the only United States location with the capability to support medium launch vehicles and to deliver payloads directly into polar orbit. MSX mission parameters call for a polar orbit in order to observe atmospheric phenomena at various earth latitudes. The other site considered, Cape Canaveral Air Force Station (CCAFS), is limited to launching vehicles into an easterly azimuth. An inflight change to a polar orbit is possible, but it would increase the fuel expenditure, thereby reducing the maximum orbital altitude to below MSX mission requirements. The Delta II booster vehicle was chosen over other launch vehicles in its class (Atlas and Titan II) based on mission performance, reliability, and schedule requirements. The Space Shuttle was also eliminated because it does not launch into a polar orbit from CCAFS.

Findings

The potential for significant impacts was determined through an analysis of the activities that would be conducted at the proposed locations. The potential impacts of the proposed action were assessed against the following environmental media: physical setting and land use; geology and water resources; air quality; noise; biological resources; threatened and endangered species; cultural resources; infrastructure; hazardous materials and waste; and public health and safety. The methodological approach consisted of identifying potential environmental issues and determining their significance. For issues identified as potentially significant after application of standard engineering practices, planned mitigation measures were incorporated into the program.

The spacecraft prelaunch and launch activities will be conducted at existing Vandenberg AFB facilities developed specifically for such activities. No significant impacts will occur as a result of these activities.

Prelaunch and launch activities of the Delta II booster will be conducted at Vandenberg AFB at existing facilities developed specifically for such activities. These activities were assessed in the *Environmental Assessment for the Modification and Operation of SLC-2W, Medium Expendable Launch Vehicle Services* (NASA, 1991), which is incorporated by reference into this EA. The analysis concluded there would be no significant impacts from the construction at the SLC-2W pad and subsequent launches of the Delta II, provided that launches do not occur during the 4 1/2-month nesting season of the California Least Tern, which nests from mid-April to the end

of August. The Delta II launch schedule for MSX is consistent with the allowable launch window identified in the SLC-2W EA.

The dedicated targets will be launched on boosters such as Strategic Target System (STARS) and Minuteman I (MMI). Only boosters with completed environmental documentation would be used. Specific targets may include: aeroshells, lightweight replicas, instrumented balloons, emissive and reflective reference spheres, chaff, debris fragments, and hydrazine fuel. Two of the dedicated target payloads will be Operational and Deployment Experiments Simulator (ODES) configuration payloads; one will be a fuel vent experiment payload, and one will be a simulated reentry vehicle. These dedicated targets are covered by existing environmental documentation. No significant impacts are expected to result from use of STARS, ODES, and MMIs for MSX, or from MSX dedicated target sets.

Cumulative impacts were evaluated at MSX fabrication, assembly, and integration testing locations, the spacecraft launch and range location, and locations and ranges for dedicated targets. Cumulative impacts will be avoided through selection of MSX activities that have been assessed programmatically and through compliance with applicable regulations at MSX locations.

Overall, no significant impact will result from conducting the MSX program. Therefore, no environmental impact statement will be prepared for the proposed action.

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Director
Strategic Defense Initiative Organization

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Date

Executive Summary

Executive Summary

Introduction

The Strategic Defense Initiative Organization (SDIO) was established to plan, organize, coordinate, and direct the research and testing of technologies applicable to developing a ballistic missile defense. In the 1991 State of the Union address, the President announced that the Strategic Defense Initiative (SDI) would be refocused to reflect the changing nature of threats to United States interests. This new focus on limited ballistic missile defense will consist of ground- and space-based elements to ensure continuous global detecting, tracking, and intercepting of ballistic missiles and their associated warheads. To develop an effective and viable program, the SDIO needs to demonstrate the capability to acquire and track midcourse targets against realistic backgrounds at system-representative distances, trajectories, and altitudes. The Midcourse Space Experiment (MSX) will integrate and functionally demonstrate state-of-the-art technologies for system elements. MSX is the only major midcourse mission planned. The MSX mission will be carried out by a single satellite carrying a variety of sensors. It is a necessary demonstration-validation activity for the development of defense against limited ballistic missile strikes.

The Proposed Action

The Strategic Defense Initiative Organization is proposing to operate the MSX spacecraft to gather information related to the following objectives: demonstration of infrared and visible midcourse sensor functions; collection of multi-spectral midcourse target and background data bases; integration of critical sensor technologies; and demonstration of surveillance from space. These purposes will be accomplished through the use of the Space Infrared Imaging Telescope (SPIRIT III) and other instrumentation that will be launched on the MSX spacecraft on a Delta II booster from Vandenberg Air Force Base (AFB) into a polar orbit. MSX will observe a variety of targets, both dedicated and nondedicated. In addition to the dedicated targets, the MSX program will involve targets not driven by or attributable to MSX. Ancillary sensors, such as Air Force Maui Optical Station (AMOS), will be used to verify and validate the MSX sensor data. Activities by these sensors will be conducted as part of their normal program operations.

Fabrication, assembly, and testing activities for the experiments to be contained on the MSX spacecraft will be conducted at Utah State University/Space Dynamics Laboratory (USU/SDL), Johns Hopkins University/Applied Physics Laboratory (JHU/APL), and Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL). The proposed activities will be conducted in existing facilities and will be within the scope of activities that are routinely conducted at those facilities.

Integration and testing activities for the spacecraft will occur at JHU/APL and the National Aeronautics and Space Administration (NASA)/Goddard Space Flight Center (GSFC). Following these activities, the spacecraft will be purged of any leftover fluids and shipped via C-5A military

cargo aircraft to Vandenberg AFB, where it will be launched into a polar orbit on a Delta II rocket. The preflight and flight activities required for the launch will be conducted at Vandenberg AFB at existing facilities developed specifically for such activities.

Alternatives

Alternatives considered include no action, the use of other launch locations, and the use of other launch vehicles. The no action alternative was rejected because if the action did not occur, the actual flight test data that is expected to result from the experiments would not be available for the continued development of space-based sensors. The mission requirements for midcourse sensors development would not be met. Vandenberg AFB was selected as the launch location because it is the only United States location with the capability to support medium launch vehicles and to deliver payloads directly into polar orbit. MSX mission parameters call for a polar orbit in order to observe atmospheric phenomena at various earth latitudes. The other site considered, Cape Canaveral Air Force Station (CCAFS), is limited to launching vehicles into an easterly azimuth. An inflight change to a polar orbit is possible, but would increase the fuel expenditure, thereby reducing the maximum orbital altitude to below MSX mission requirements. The Delta II booster vehicle was chosen over other launch vehicles in its class (Atlas and Titan II) based on mission performance, reliability, and schedule requirements. The Space Shuttle was also eliminated because it does not launch into a polar orbit from CCAFS.

Analysis of Impacts

The potential for significant impacts was determined through an analysis of the activities that would be conducted at the proposed locations. As a result of that analysis, the impacts of the proposed action were assessed against the following selected environmental media: physical setting and land use; geology and water resources; air quality; noise; biological resources; threatened and endangered species; cultural resources; infrastructure; hazardous materials and waste; and public health and safety. The methodological approach consisted of identifying potential environmental issues and determining their significance. For issues identified as potentially significant after application of standard engineering practices, planned mitigation measures were incorporated into the program.

The spacecraft prelaunch and launch activities will be conducted at Vandenberg AFB at existing facilities developed specifically for such activities. No significant impacts will occur as a result of these activities.

Prelaunch and launch activities of the Delta II booster will be conducted at Vandenberg AFB at existing facilities developed specifically for such activities. These activities were assessed in the *Environmental Assessment (EA) for the Modification and Operation of Space-Launch Complex (SLC-2W), Medium Expendable Launch Vehicle Services* (NASA, 1991). The SLC-2W EA is incorporated by reference into this EA. This analysis concluded there would be no significant impacts from the construction at the SLC-2W pad and subsequent launches of the Delta II, provided that the launches do not occur during the 4 1/2-month nesting season of the California Least Tern, which nests from mid-April to the end of August. The Delta II launch schedule for MSX is consistent with the allowable launch window identified in the SLC-2W EA.

Dedicated targets will be launched on boosters such as the Strategic Target System (STARS) and Minuteman I (MMI). Only boosters with completed environmental documentation will be used. Specific targets may include: aeroshells, lightweight replicas, instrumented balloons, emissive and reflective reference spheres, chaff, debris fragments, and hydrazine fuel. Two of the dedicated target payloads will be Operational and Deployment Experiments Simulator (ODES) configuration payloads; one will be a fuel vent experiment payload, and one will be a simulated reentry vehicle. These dedicated targets are covered by the following environmental documentation: Environmental Assessment, Strategic Target System (STARS), July 1990 (USASDC); Supplement to the Strategic Target System (STARS) EA, July 1991 (USASDC); Environmental Assessment, Minuteman & Thor Missile Launches at VAFB, California, April 1976 (USAF); and Record of Environmental Consideration (REC), Operational and Deployment Experiments Simulator (ODES), December, 1990 (USASDC).

Launch profiles and target characteristics for dedicated MSX launches were compared to, and found to be consistent with, those assessed in the STARS EA and supplement, and the ODES REC. In addition, MMI launches and target payloads are comparable to those assessed in the referenced EA and routinely experienced at Vandenberg AFB. No significant impacts are expected to result from use of STARS, ODES, and MMIs for MSX or from MSX dedicated target sets.

Cumulative impacts were evaluated at MSX fabrication, assembly, and integration testing locations, the spacecraft launch and range location, and locations and ranges for dedicated targets. Cumulative impacts will be avoided through selection of MSX activities that have been assessed programmatically and through compliance with applicable regulations at MSX locations.

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List of Acronyms

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AFB	Air Force Base
AMOS	Air Force Maui Optical Station
ANSI	American National Standards Institute
ARAR	Accident Risk Assessment Report
ATG	Aerospace Test Group
BE	Brilliant Eyes
BOA	Broad Ocean Area
CCAFS	Cape Canaveral Air Force Station
CE	Contamination Experiment
CEQ	Council on Environmental Quality
cfe	consolidated front end
CFR	Code of Federal Regulations
CSTC	Consolidated Space Test Center
DOD	Department of Defense
DOPAA	Description of Proposed Action And Alternatives
DOT	Department of Transportation
EA	Environmental Assessment
EDX	Exoatmospheric Discrimination Experiment
E^2I	Endo-Exoatmospheric Interceptor
EIS	Environmental Impact Statement
ELV	Expendable Launch Vehicle
ESQD	Explosive Safety Quantity Distance
ER	Eastern Range
FONSI	Finding of No Significant Impact
GBI	Ground Based Interceptor
GHA	Ground Hazard Area
GSFC	Goddard Space Flight Center
GSTS	Ground-based Surveillance and Tracking System
HALO/IRIS	High Altitude Learjet Observatory and Infrared Instrumentation System
ICBM	Intercontinental Ballistic Missile
JHU/APL	John Hopkins University/Applied Physics Laboratory
KSC-V	Kennedy Space Center-Vandenburg
KTF	Kauai Test Facility
KREMS	Kiernan Reentry Measurement Site
LEO	Low Earth Orbit
LV	Launch Vehicle
LWIR	Long Wavelength Infrared
μCi	microcurie
MCC	Mission Control Center

MIT/LL	Massachusetts Institute of Technology/Lincoln Laboratory
mJ	millijoule
mW/cm^2	milliwatts per square centimeter
MMI	Minuteman I
MPC	Mission Processing Center
MSX	Midcourse Space Experiment
NASA	National Aeronautics and Space Administration
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NO_x	Oxides of Nitrogen
nm	nanometer
nmi	nautical mile
NRL	Naval Research Laboratory
OAMP	Optical Aircraft Measurement Program
ODES	Operational and Deployment Experiments Simulator
OSDP	Onboard Signal Data Processor
PBV	Post Boost Vehicle
PCF	Payload Command Facility
PM	Particulate Matter
PPF	Payload Processing Facility
ppm	parts per million
PSD	Prevention of Significant Deterioration
QCM	Quartz-Crystal Microbalance
RADOT	Recording Automatic Ditigal Optical Trackers
REC	Record of Environmental Consideration
RF	radio frequency
RP-1	kerosene
RV	Reentry Vehicle
SAC	Strategic Air Command
SBCAPCD	Santa Barbara County Air Pollution Control District
SBV	Space Based Visible Surveillance Sensor
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
SHPO	State Historic Preservation Officer
SLAMS	State and Local Air Monitoring Station
SLBM	Sea Launched Ballistic Missile
SLC	Space Launch Complex
SPIRIT III	Space Infrared Imaging Telescope
SPW	Space Wing
SSD	Space Systems Division
STARS	Strategic Target System
SUPER	Survivable Solar Power Subsystem (Module) Demonstrator
TNS	Sensor Technology Directorate/SDIO
TSP	Total Suspended Particulate
UDMH	Unsymmetrical Dimethyl Hydrazine

USAF	U.S. Air Force
USAKA	U.S. Army Kwajalein Atoll
USASDC	U.S. Army Strategic Defense Command
USU/SDL	Utah State University/Space Dynamics Laboratory
UVISI	Ultraviolet/Visible Imagers and Spectrographic Imagers
WSMC	Western Space and Missile Center
WR	Western Range

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Purpose and Need for the Proposed Action 1.0

Midcourse Space Experiment Environmental Assessment

The National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ) regulations that implement NEPA (40 CFR 1500-1508), and the U.S. Department of Defense (DOD) Directive 6050.1 require that DOD officials take into account environmental consequences when authorizing or approving major Federal actions in the United States. Accordingly, this environmental assessment (EA) analyzes the potential environmental consequences of all aspects of the proposed Midcourse Space Experiment (MSX).

Section 1.0 describes the purpose and need for the proposed action. Section 2.0 describes the proposed action and its alternatives, including the no-action alternative. For particular activities that have the potential to significantly affect the environment, mitigation measures are incorporated into the MSX program to reduce the potentially significant effects to insignificant levels. These mitigation measures will be implemented as a part of the MSX program. Section 3.0 describes the affected environment at installations and locations where the testing and launch activities will be conducted. Section 4.0 assesses the potential environmental consequences of the proposed action at these installations.

1.0 Purpose and Need for the Proposed Action

The Strategic Defense Initiative Organization (SDIO) was established to plan, organize, coordinate, and direct the research and testing of technologies applicable to developing a ballistic missile defense. In the 1991 State-of-the-Union address, the President announced that the Strategic Defense Initiative (SDI) would be refocused to reflect the changing nature of threats to U.S. interests. This new focus on limited ballistic missile defense will consist of ground- and space-based elements to ensure continuous global detecting, tracking, and intercepting of ballistic missiles and their associated warheads. To develop an effective and viable program, the SDIO needs to demonstrate the capability to acquire and track midcourse targets against realistic backgrounds at system- representative distances, trajectories, and altitudes. The ability to acquire targets in midcourse flight is essential to the effectiveness of the system. MSX will integrate and functionally demonstrate state-of-the-art technologies for system elements, as well as provide a comprehensive midcourse phenomenologies database. MSX is the only major midcourse mission planned. The MSX mission will be carried out by a single satellite carrying a variety of sensors. It is a necessary demonstration-validation activity for the development of defense against limited ballistic missile strikes (PRA, 1991b).

The purposes of the proposed MSX program are: demonstration of infrared and visible midcourse sensor functions; collection of multi-spectral midcourse target and background data; integration of critical sensor technologies; and demonstration of space surveillance capabilities (SDIO, 1990a). The primary objective of the MSX program is to resolve the above technology issues, which are critical to the success of midcourse sensor systems for key ground- and space-

based elements in the system architecture. Using the instrumentation on the satellite on a mission lifetime of several years in polar orbit, MSX will provide functional demonstrations and integrate state-of-the-art technologies necessary for the development of the current system elements. MSX will aid the development of the following programs (and their functional equivalents): Brilliant Eyes (BE); Ground-Based Interceptor (GBI); Endo-Exoatmospheric Interceptor (E^2I); and the Ground-based Surveillance and Tracking System (GSTS) (SDIO, 1991a).

Description of Proposed Action and Alternatives 2.0

2.0 Description of Proposed Action and Alternatives

2.1 Proposed Action

The proposed action is to develop, launch, and operate the MSX spacecraft and to conduct a target program. MSX is primarily a data-collection experiment, concentrating on the phenomenology of target detection and tracking. The MSX sensors will also gather both celestial and earth limb background data. These instruments, as well as ancillary ground sensors, will observe a series of dedicated and nondedicated targets. MSX will be a space-based sensor experiment, serving as a data-gathering tool for the ballistic missile defense sensor elements.

Activities required to support MSX are execution of component/assembly tests for the MSX spacecraft experiments, prelaunch and launch activities, on-orbit activities, and target activities.

2.1.1 Concept and Background of MSX

In the 1980s, the Defensive Technologies Study, or Fletcher Study, concluded that the most effective strategic defensive systems would have multiple layers. The concept of multilayered defense continues as the conceptual cornerstone for SDIO. Specifically, the current system consists of layers referred to as boost/postboost, midcourse, and terminal. These layers correspond, respectively, to (1) the period of a ballistic missile's flight beginning with the thrusting of the booster and continuing on through the time its RVs and possible decoys are deployed, (2) the relatively long period of time RVs and decoys coast along their ballistic trajectories in space, and (3) the final period when the RVs reenter the atmosphere near their targets.

The goal of the program for limited ballistic missile defense is to intercept all the attacking warheads and deny any damage: a low leakage system. (Leakage is a measure of the number of warheads that penetrate the defense.) A successful intercept requires detecting and tracking a target, discriminating the target from decoys and debris, launching interceptors, hitting the target, and finally destroying the target. The preferred approach to reduce leakage is to deploy a multi-tiered defense, with each tier capable of independently performing the basic functions of threat detection, tracking, identification, pointing or weapon guidance, destruction, kill assessment, coordination, and self-defense. If an element within a single tier fails, the target leaks through to the next tier, where the defense has another chance to detect and intercept the target.

The leakage of RVs can best be reduced by using a system of layered sensors and interceptors based in space and on the ground. Space-based sensors can detect the booster and postboost vehicle (PBV) exhaust plumes or the RVs after release from the PBV, track the flight of these objects, and direct space-based or ground-based interceptors to intercept and destroy them. If the intercept is unsuccessful, then the terminal layer of defense (ground-based sensors and interceptors) can try to intercept the RVs before they reach their intended targets. The space-based sensors play an important role in this process.

The space-based sensors must be able to detect the plumes of the booster or PBV or the relatively cool RVs during flight. These sensors must also be able to determine whether or not the interceptor(s) destroyed the booster, PBV, or RV in flight (kill assessment) to enable the battle manager to determine whether or not to try to engage these objects with the terminal defenses. These sensors must also be capable of discriminating between RVs and decoys.

To perform these functions, several types of sensors are required that must be developed and tested in a realistic environment. The MSX program is designed to aid in the development and testing of these space- and ground-based sensor systems.

The MSX spacecraft (see Figure 2-1) will include as its primary payload the Space Infrared Imaging Telescope (SPIRIT III), a cryogenically cooled long wave infrared (LWIR) interferometer and radiometer developed by Utah State University/Space Dynamics Laboratory (USU/SDL). Secondary payloads will include a system of ultraviolet/visible imagers and spectrographic imagers (UVISI) developed by Johns Hopkins University/Applied Physics Laboratory (JHU/APL); a Space Based Visible (SBV) surveillance sensor developed by Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL); an onboard signal/data processor (OSDP) developed by SDIO/Sensor Technology Directorate (TNS); contamination sensors; and a mirror cleaning experiment.

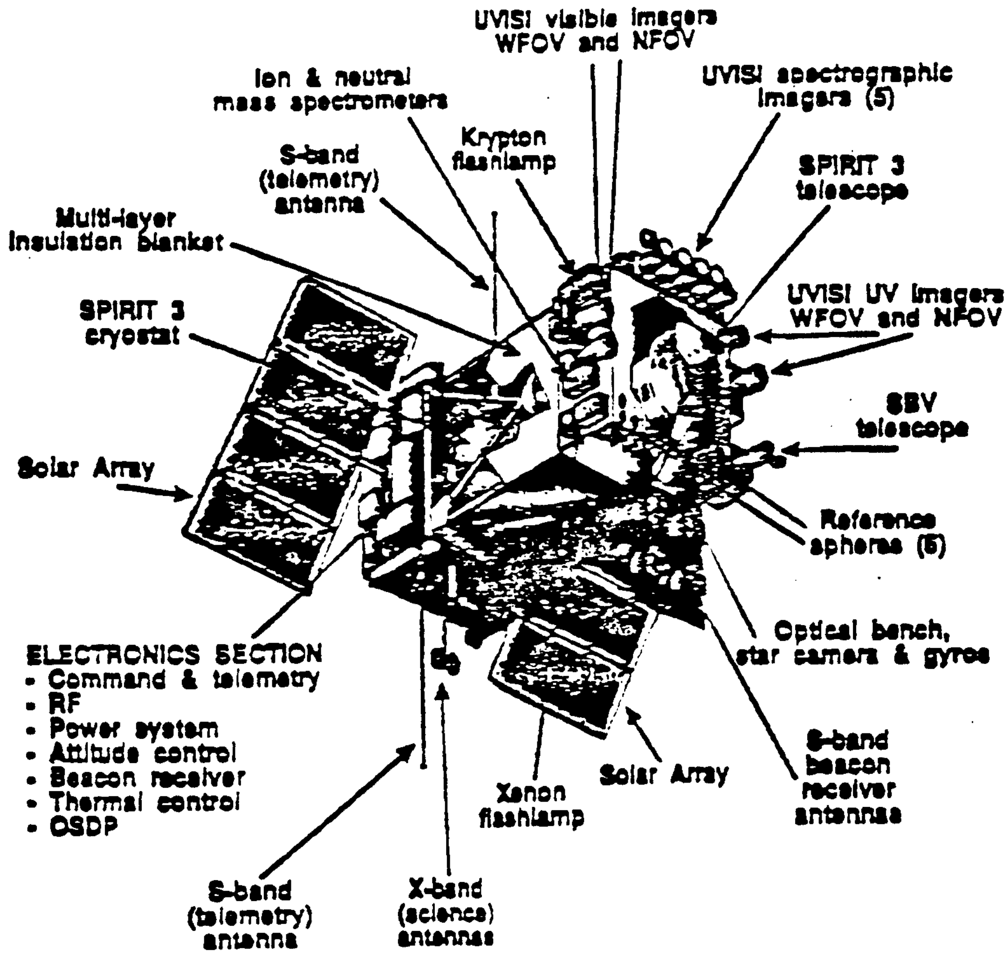
The MSX spacecraft will be launched on a Delta II vehicle into an 888 km polar orbit from Vandenberg Air Force Base (AFB) (see Figure 2-2). This orbit was chosen to provide the desired background during the midcourse flight of the dedicated target launches, and build up a consistent database on sensor background over most regions of the globe.

The MSX program will operate the spacecraft for approximately five years. It will acquire and track rockets, decoys, and penetration aids as they come into view, and demonstrate technology. The data obtained will be used to design midcourse sensors. The satellite will be shut down at the completion of MSX activities, and will remain in orbit for several hundred years.

The MSX spacecraft is solar powered with a battery backup. The battery is capable of providing output for expected loading and cycling for approximately five years (the expected lifetime of the satellite).

2.1.2 Component Assembly and Testing of the MSX Spacecraft Experiments

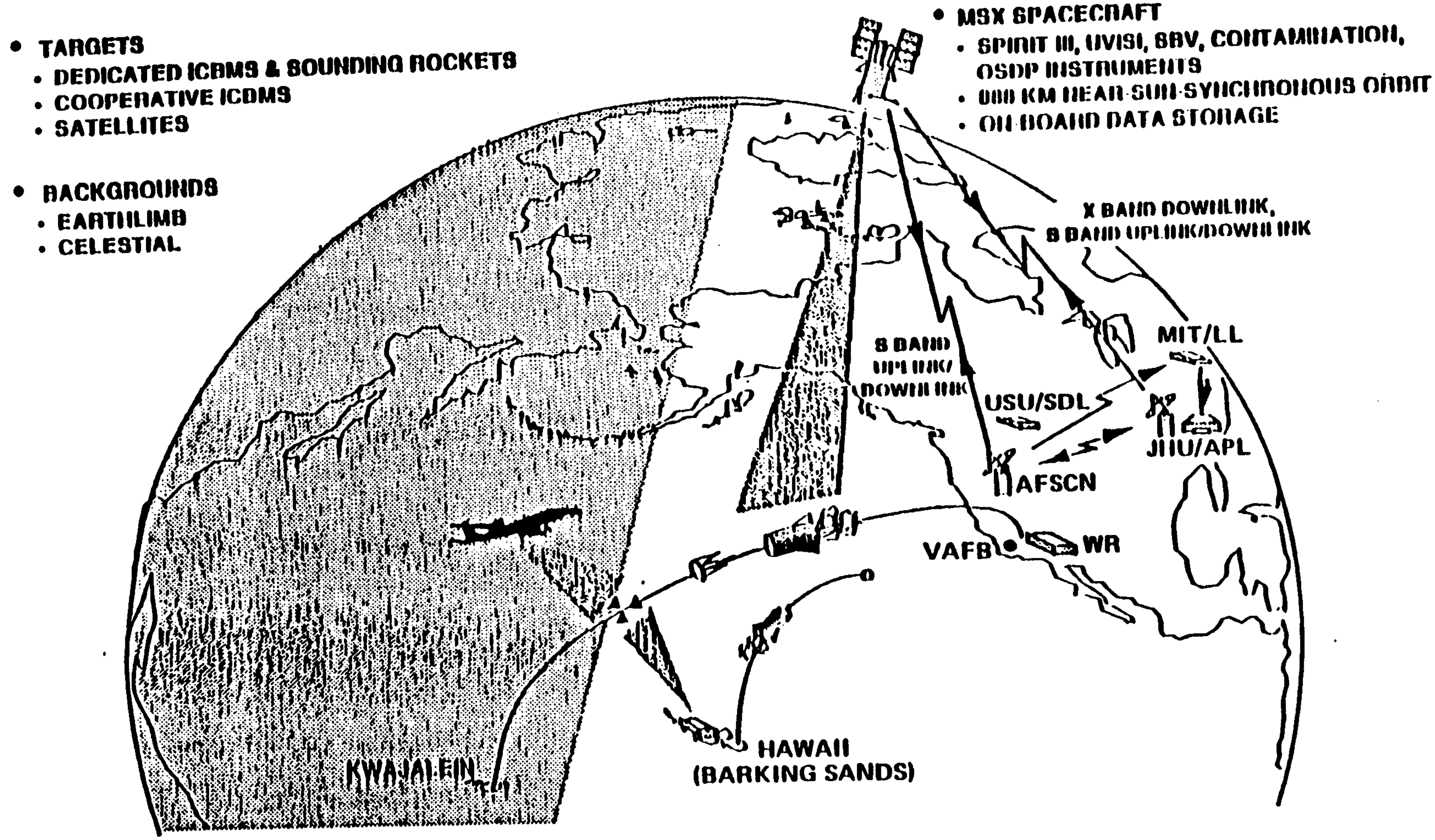
To support the MSX Program, component assembly and ground testing of the spacecraft experiments will occur at contractor and Government facilities in the continental United States. Table 2-1, MSX Activities and Locations, provides an overview of all the activities that are required for the MSX program, from the fabrication and assembly of the components to the launch of the spacecraft. JHU/APL will provide MSX system engineering, satellite development, and payload integration. Therefore, JHU/APL is responsible for the overall design, fabrication, inspection, assembly, and testing of the satellite and its subsystems.



MSX SPACECRAFT PHYSICAL CHARACTERISTICS	
Weight	5720 lbs
Height	12.66 ft
Cross Section (Solar Arrays Undeployed)	5 ft
Solar Array Dimensions (Deployed)	5 ft by 10 ft (each)

Figure 2-1
MSX SPACECRAFT: ARTIST CONCEPT
AND PHYSICAL CHARACTERISTICS

SOURCE: JHU/APL, 1991b



SOURCE: JHU/APL, 1990a

FIGURE 2-2
MSX PROGRAM MISSION CONCEPT

TABLE 2-1 MSX ACTIVITIES AND LOCATIONS

ACTIVITY	LOCATION[1]					
	MIT/LL	USU/SDL	JHU/APL	GSFC	VAFB	KTF
Fabrication	-SBV -Reference Objects	-SPIRIT III	-Satellite[2] -UVISI			
Assembly	-SBV -Reference Objects	-SPIRIT III	-Satellite -UVISI			
Testing	-SBV -Reference Objects	-SPIRIT III -OSDP[2] -Mirror Cleaning Experiment[2]	-Satellite -UVISI -Contamination Experiment[2]			
Integration/ Testing			-Satellite -SPIRIT III -SBV -UVISI -Reference Objects -OSDP -Contamination Experiment -Mirror Cleaning Experiment			
Environmental Testing[3]				-Satellite with all experiments/ instruments		
Satellite Prelaunch Integration/ Testing					-Delta II	
Satellite Launch					-Delta II	
Target Prelaunch Integration/ Testing					-Minuteman I	STARS
Target Launch					-Minuteman I	STARS

1 Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL)
Utah State University/Space Dynamics Laboratory (USU/SDL)
John Hopkins University/Applied Physics Laboratory (JHU/APL)
NASA/Goddard Space Flight Center (GSFC)
Vandenberg Air Force Base (VAFB)
Kauai Test Facility (KTF)

2 Satellite truss structure, OSDP, mirror cleaning experiment, and contamination experiment provided by subcontractors.

3 Environmental testing activities simulate operation in the space environment and are unrelated to determinations of significant impacts on the environment.

JHU/APL is also responsible for the UVISI sensor and the Contamination Experiment (CE). The UVISI sensor will provide complete spectral and imaging capabilities from the far ultraviolet (100 nm) to the near infrared (900 nm) wavelengths. The UVISI is derived from a succession of ultraviolet and visible instruments previously flown on orbital missions by JHU/APL. It will have larger optics than earlier instruments and closed-loop tracking capability. The current design gives the UVISI a design lifetime of four to five years. Components of the UVISI will be bought from outside sources and fabricated at JHU/APL in Buildings 13 and 14. Fabrication activities will use existing facilities, procedures, and personnel, and will consist of circuit board preparation, welding, and microelectronics laboratory activities (JHU/APL, 1990).

The CE will monitor contamination external to the spacecraft. It will provide input to determine when the onboard instruments should be turned on. It will also extend current spacecraft contamination models. The components of CE will be provided by subcontractors to JHU/APL, where assembly and testing activities will occur. Krypton and xenon flash lamps in the CE will contain a small amount of low-level Ni^{63} radioactive element. The Ni^{63} will serve as an ionizing source and will conserve power to the lamps. JHU/APL has the necessary use and possession licenses required for these materials. Radiation emitted from Ni^{63} is small enough (80 microcuries (μCi)) to exempt it from Nuclear Regulatory Commission licensing and Department of Transportation (DOT) regulations for licensing, control procedures, and documentation of levels over 100 μCi (JHU/APL, 1991a).

USU/SDL will design, assemble, and test the SPIRIT III sensor, the primary payload package. The tests will be executed in existing specialized chambers that will simulate space conditions. Cold and warm environment tests, a cold calibration test, an integration test for the liquid hydrogen storage dewar (similar to a vacuum bottle or thermos), and hydrogen cold tests are the milestone tests planned for SPIRIT III (USU/SDL, 1991a). The operational lifetime of the SPIRIT III sensor will be approximately two years.

USU/SDL will also perform test activities for the OSDP and the CE. The OSDP will demonstrate real-time signal/data processing of LWIR data in space. It will perform time-dependent and object-dependent signal processing for a portion of the data from the SPIRIT III radiometer focal plane. The mirror cleaning experiment for the SPIRIT III mirror will consist of a pulsed CO_2 laser operating on a movable arm. Laser power output from the sensor is 285 millijoules (mJ) per 4-microsecond (μS) pulse in a 1-centimeter beam, with a pulse repetition of 2 hertz (Hz) (USU/SDL, 1992). The mirror cleaner is designed to restore mirror performance as near as possible to pre-flight levels. The primary sources of degradation to the mirror will be from the spacecraft itself—heavy organic molecules "outgassing" from the spacecraft and from particles floating free from the spacecraft. Mirror contamination will also occur from dust and the small amounts of gasses found in space. The primary mirror will be cleaned on-orbit to test the cleaning concept.

MIT/LL will design and assemble the SBV instrument. Components of the instrument will be fabricated in a clean room in Building I. Electronic simulation and assembly testing of the instrument will also occur at MIT/LL (MIT/LL, 1991b). The SBV sensor is designed to demonstrate an above-the-horizon surveillance capability from a space platform using a visible wavelength optical sensor. MIT/LL will also provide at least four reference objects. The

reference objects will be used for instrument calibration purposes and to evaluate flight sensor performance and precision. The objects will be approximately 2 cm in diameter, be made of aluminum, and have an ejection velocity of 13 meters per second. They will be fabricated at MIT/LL in Building D, the Environmental Test Laboratory (MIT/LL, 1991a).

2.1.3 System Integration Testing Activities

The experiments discussed in Section 2.1.2 and their support and calibration equipment will be shipped via commercial truck and air carriers to JHU/APL for integration and testing. All shipments will consist of standard equipment and nonhazardous materials. Therefore, no special transportation permits will be required (MIT/LL, 1991a; USU/SDL, 1991a).

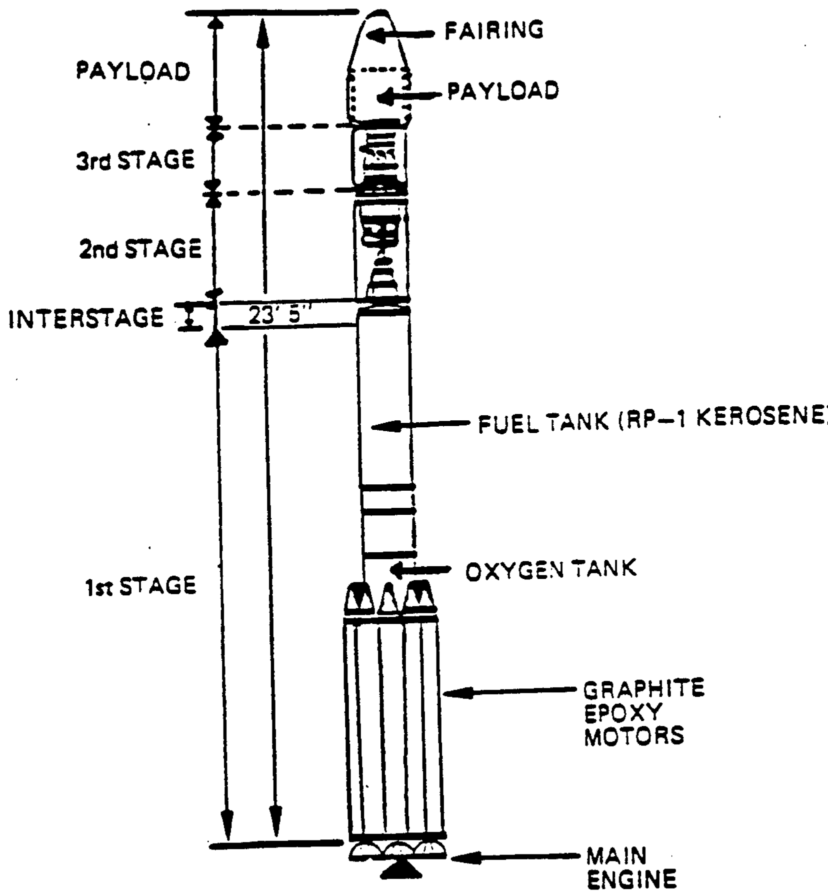
Integration of the experiments, as well as engineering testing, software checkout, and attitude control simulations for the spacecraft will be conducted at JHU/APL in Building 23. This building contains the clean rooms required for the system test and checkout procedures. Outdoor testing of the completed spacecraft's communications and other electronic systems will take place at JHU/APL's outdoor antenna test range. The SPIRIT III cryostat will be cooled with liquid helium for the tests to be performed at JHU/APL and at the National Aeronautics and Space Administration/Goddard Space Flight Center (NASA/GSFC) in Greenbelt, Maryland.

Once the initial integration tests listed above are completed, the spacecraft will undergo further testing to be conducted in existing indoor facilities at NASA/GSFC, Building 7. These tests include optical alignments and verifications; acoustical environment exposure; pyro-shock and deployments exposure; magnetic tests; launch vehicle (LV) and spacecraft separation tests; and thermal vacuum exposure tests (JHU/APL, 1990). Liquid helium and gaseous nitrogen are used during the integrated testing activities. The helium evaporates during use and is vented to the atmosphere. The gaseous nitrogen is also vented to the atmosphere. Both helium and nitrogen occur naturally in the atmosphere.

Following the integration and testing activities at JHU/APL and NASA/GSFC, the spacecraft will be transported by truck to Andrews AFB in Washington, D.C., and shipped via C-5A military cargo aircraft to Vandenberg AFB in California. The spacecraft will not contain any fluids during shipment.

2.1.4 MSX Launch Vehicle and Flight Profile

The MSX spacecraft will be launched on a Delta II (7920 configuration) from Space Launch Complex-2West (SLC-2W) at Vandenberg AFB (see Figures 2-3 and 2-4). The SLC-2W is currently configured to launch Delta I vehicles. Refurbishment of the SLC-2W is planned during 1991 and 1992 to accommodate all future Delta II launches. The launch frequency of the Delta II program will be two per year, including the single MSX launch. Launches will not occur during the 4 1/2-month nesting season of the California Least Tern, which has its habitat in the coastal dunes to the west of SLC-2W, and nests from mid-April to the end of August. Construction and subsequent operation of SLC-2W is examined in the *Environmental Assessment for the modification and operation of SLC-2W, Medium Expendable Launch Vehicle Services* (NASA, 1991a). The SLC-2W EA and Finding of No Signicant Impact (FONSI) are



SOURCE: NASA, 1991

FIGURE 2-3
DELTA II LAUNCH VEHICLE CONFIGURATION

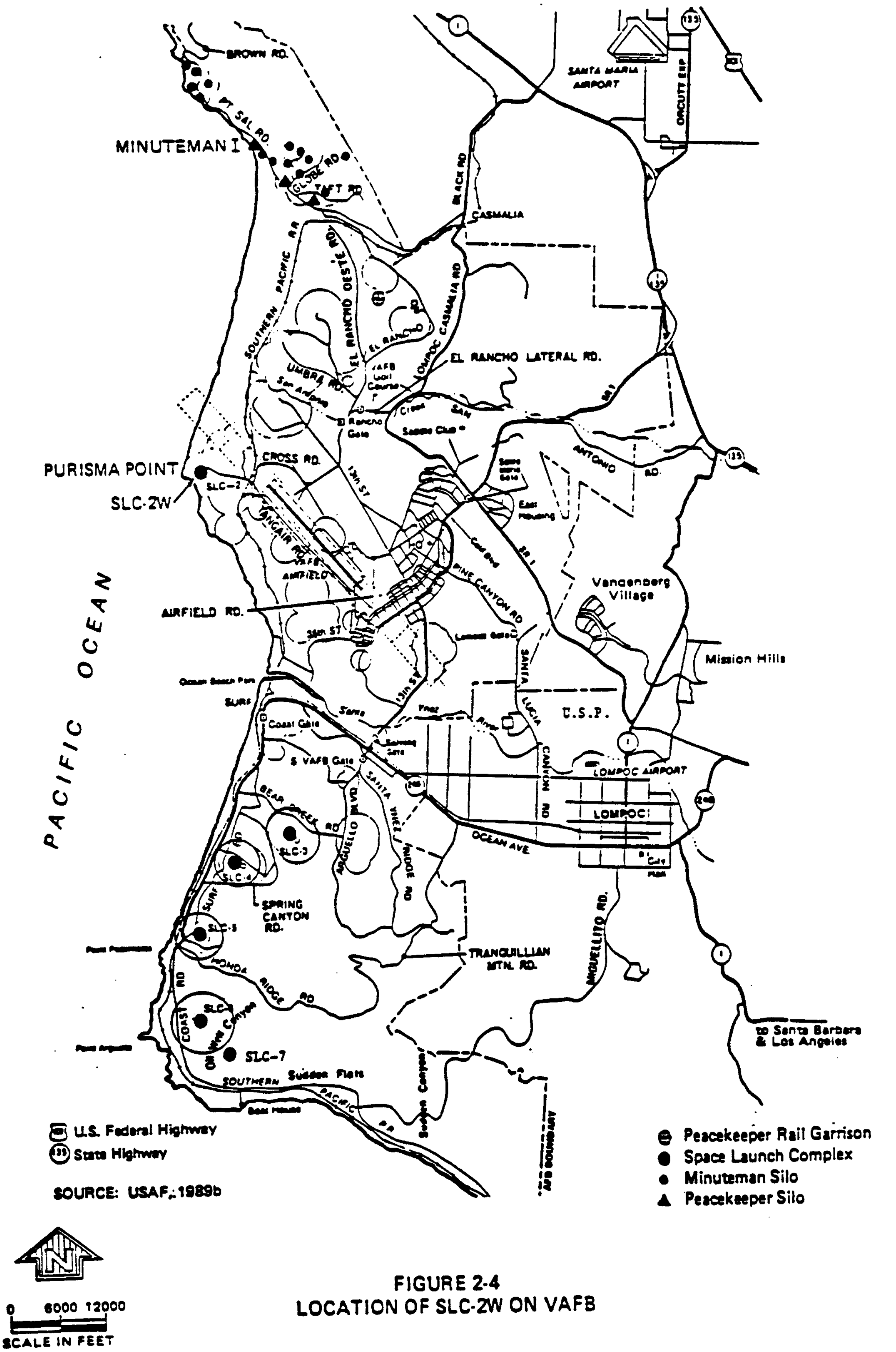


FIGURE 2-4
LOCATION OF SLC-2W ON VAFB

incorporated by reference and summarized in the appropriate sections of this document. MSX payload processing and handling are not covered in the SLC-2W EA and are summarized in the following sections.

2.1.5 Prelaunch and Launch Activities

Prelaunch activities extend from arrival of the spacecraft and launch vehicle at Vandenberg AFB to the time the vehicle is assembled, checked-out, and ready for launch. Prelaunch and launch activities for the Delta II launch are as assessed in the SLC-2W EA. Activities described in this section are attributable to the MSX payload.

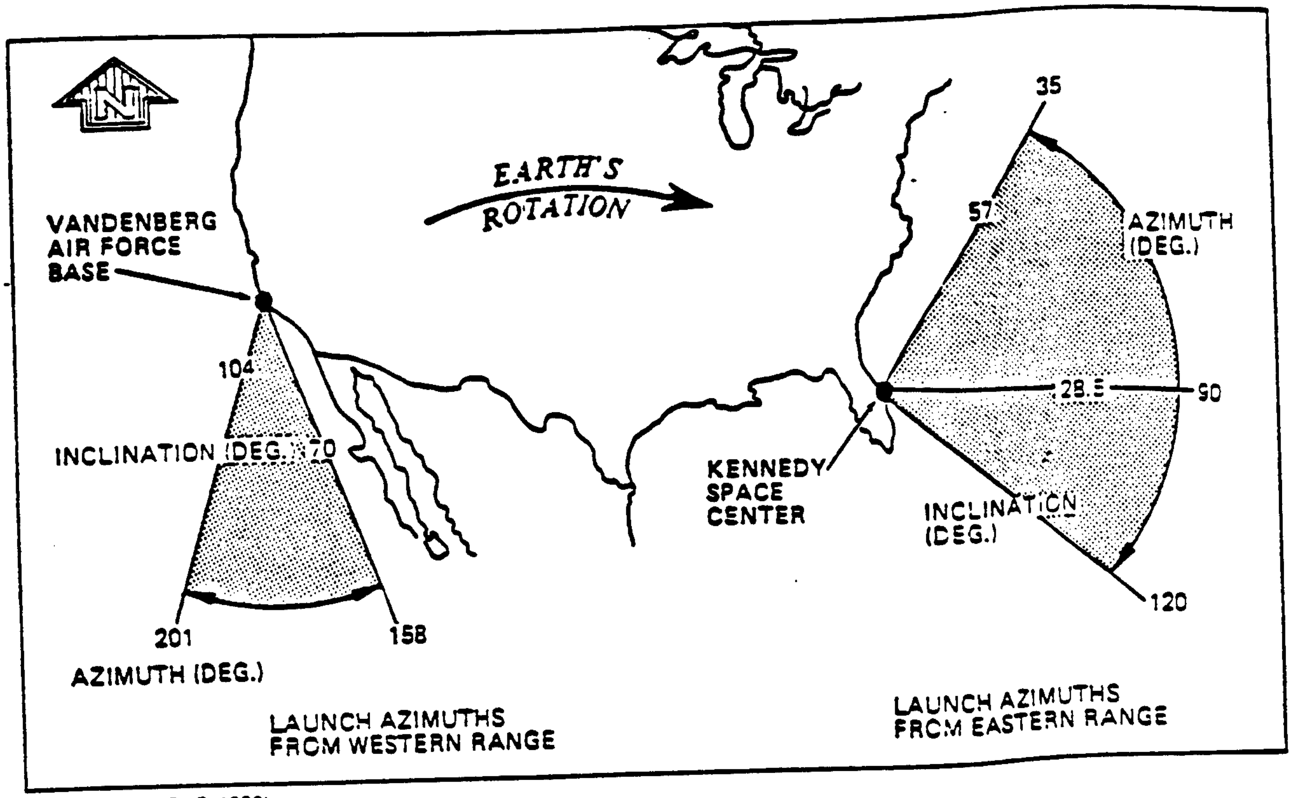
The MSX spacecraft will be launched at a 99.16 degree inclination, 888 km polar orbit. This orbit will provide the desired background covering the whole globe for the sensor experiments during the midcourse flight.

The MSX spacecraft will arrive at Vandenberg AFB aboard a C-5 military cargo aircraft from Andrews AFB. The spacecraft itself will be transported to NASA Building 1610, known as the Payload Processing Facility (PPF), on the North Base portion of Vandenberg AFB. Accompanying ground support equipment will be transported to and installed in NASA Building 836, known as the Payload Command Facility (PCF), on South Base. The PPF houses the MSX spacecraft for the prelaunch operations (installation of payload fairing, battery charging, etc.), while the PCF controls it during prelaunch testing. Building 7011 on North Base, operated by the 30th Space Wing (30SPW) is the primary node in an existing communications network linking the PPF and the PCF to each other, as well as to Consolidated Space Test Center (CSTC), to JHU/APL (via NASA/GSFC), and to the launch operations control center located in Building 7000.

All prelaunch processing will take place in the PPF. Activities will include: unpacking the spacecraft from its shipping container; charging the onboard nickel-hydrogen batteries; filling the cryostat with solid hydrogen; verifying the alignment of the onboard optical systems; arming the onboard pyrotechnic systems (explosive bolts); and placing the fairing on top of the payload. The spacecraft will then be transported to the SLC-2W launch pad, where it will be mated with the Delta II launch vehicle. A series of preflight system verification tests, directed from the PCF, will follow. These tests will include a spacecraft electrical systems test and a radio-frequency interference test. The SPIRIT III door dewar will then be filled with cryogen (liquid argon) and the payload fairing installed, completing prelaunch preparation.

Launch activities extend from the launch countdown and launch through orbit insertion (spacecraft separation). Activities include: launch countdown and control; range safety booster tracking; and spacecraft orbit insertion verification.

The specific information regarding the MSX launch azimuth, trajectory, and impact areas has not yet been developed. The launch will occur, however, within the range of polar of polar launch azimuths from Vandenberg AFB as shown in Figure 2-5. These azimuths and Vandenberg AFB's geographic location allow the MSX spacecraft to be placed in a high inclination polar orbit without overflying heavily populated areas.



SOURCE: USAF, 1989b

FIGURE 2-5
OVER-WATER ORBITAL LAUNCH AZIMUTHS POSSIBLE FROM THE TWO PRINCIPAL U.S. SPACE PORTS

2.1.6 Ground and Flight Safety

JHU/APL provides integrated safety management to assure comprehensive accident risk assessment for the entire life cycle of the MSX spacecraft from design through the end of the mission (JHU/APL, 1992). The MSX Integrated Safety Program encompasses the System Safety Program (which covers the MSX program from design through launch and orbital insertion) and the Space Safety Program (which covers the on-orbit activities of the MSX spacecraft). The Integrated Safety Program also reflects the MSX interface with the ground and flight safety plans by the Delta II launch vehicle contractor.

Safety planning for the MSX program is proceeding concurrently for all program phases, with initial detailed emphasis on ground safety during spacecraft development and testing. Major program safety milestones related to ground activities include approval of procedures related to spacecraft environmental testing (in late 1992) and prior to spacecraft shipment (in early 1993). Flight and orbital safety milestones have been established to support a Fall 1993 launch. Through mid-1992, preliminary plans have been completed for review. Completed safety documentation for MSX will be available at all MSX activity sites (JHU/APL, 1992).

Safety requirements imposed on the MSX spacecraft and its ground, flight, and space test operations include those by the JHU/APL and its contractors for spacecraft development and environmental testing; NASA/GSFC for spacecraft environmental testing; Kennedy Space Center (KSC) for spacecraft processing and launch site operations; McDonnell Douglas Space Systems (MDSSC) Company for launch vehicle integration operations; the 30SPW for all Vandenberg AFB operations including launch; and the CSTC for space test operations. Safety guidelines, specifications, and safety standards for the MSX design and ground, launch, and space test operations include the following (JHU/APL, 1992):

- CSTCR 127-1, "Consolidated Space Test Range Safety Requirements," 30 August 1990.
- WSMCR 127-1, "Western Space and Missile Center Range Safety Requirements," 15 May 1985.
- AFOSH STD 161-9, "Exposure to Radiofrequency Radiation," 12 February 1987.
- AFOSH STD 161-10, "Health Hazards Controls for Laser Radiation," 30 May 1980.
- KMI 1710.1F, "KSC Safety, Reliability, and Quality Assurance Programs," 21 April 1988.
- KMI 1710.13E, "Technical Operating Procedures Policy, " 30 April 1987.
- K-SF-0003.7, "Ground Safety Plan, Offsite Facility,VAFB," March 1986.
- MDSSC Document MDC H3224B, "Payload Planners guide, Section 10," December 1989.
- NSS/GO-1740.9, "NASA Safety Standard for Lifting Devices and Equipment," July 1988.
- DI-S-30565B, "Accident Risk Assessment Report (ARAR)," 8 March 1985.
- DI-SAFT-80100, "System Safety Program Plan," 20 January 1986.
- DI-SAFT-80101, "System Safety Hazard Analysis Report," 20 January 1986.
- MIL-STD-454L, "Standard General Requirements for Electronic Equipment," 30 June 1989.

- MIL-STD-1522A, "Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems," 28 May 1984.
- MIL-STD-1574A, "System Safety Program for Space and Missile Systems," 15 August 1979.
- MIL-STD-1576, "Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems," 31 July 1984.

System Safety has been evaluated in accordance with the criteria in MIL-STD-1574A. Through application of the plan, potential safety hazards are identified, evaluated, and eliminated or controlled. Potential hazards are identified during the course of engineering design and regularly scheduled safety reviews. Each MSX system and subsystem is evaluated for potential release of energy that could result in personnel injury, damage to the MSX spacecraft and surrounding equipment/facilities, other spacecraft, and the environment.

Hazards for ground and flight operations were evaluated in the Accident Risk Assessment Report (ARAR) in twelve specific areas (failure under acceleration, asphyxiation hazard; contamination/toxicity hazard; electrical hazard; fire/explosion hazard; hazardous materials; impact hazard; noise; pressure hazard; ionizing radiation; non-ionizing radiation; and temperature) and presented in a hazard analysis matrix. Procedures for storage, assembly, and prelaunch operations that involve gaseous hydrogen (potential fire/explosion and asphyxiation hazards) are being developed. Other potential hazards have been found to be mitigable through implementation of standard safeguards and procedures.

Ground and flight safety plans for the Delta II launch vehicle are in development by the vehicle contractor, in conjunction with the U.S. Air Force (USAF) 30SPW/SE and NASA. The safety plans will include standard operating procedures for storage, assembly, prelaunch, and launch operations. Key procedures will be included for solid and liquid fuels handling (both are used on the Delta II) at SLC-2W, ground safety area implementation, worker and spectator protection from noise and launch emissions, and range clearing/security for marine vessels and aircraft. These launch vehicle-specific procedures will be integrated with those for the MSX payload, including those for venting cryogenic hydrogen. Overall, the MSX spacecraft will not require extensive modification of vehicle-specific procedures for the MSX mission.

Hazard categories that apply to space operations and testing include six areas (collision with another object in space; explosion on orbit; directed energy emissions; electromagnetic interference; ionizing radiation; and chemical releases) are evaluated in the Test Operations Risk Assessment (TORA) report. The TORA enables CSTC in assessing MSX test operations for an acceptably low risk to the general public and the space environment.

2.1.7 On-Orbit Activities

On-orbit activities will begin at orbit insertion with the handover from Ground Operations to Flight Operations, the start up of spacecraft systems, and an evaluation of their operation. Once checkout, calibration, and characterization activities are completed, a mini-MSX mission will be conducted. This mission involves collecting data from all onboard experiments, over a period of several days, to verify operation of all systems (JHU/APL, 1990). Reference objects released

from the MSX platform will be used to calibrate the SPIRIT III sensor (see Section 2.1.1). There will be no chemical releases for calibration purposes.

MSX mission experiments will extend from checkout through the end of the spacecraft's operational life, approximately five years. The lifetime of the SPIRIT III sensor is dependent upon the amount of available hydrogen cryogen. Hydrogen will be released to space on a regular basis from the dewar on the SPIRIT III sensor. Approximately a one-quarter pound of hydrogen will be released per day, for a total of 172 pounds over the sensor lifetime, to maintain sensor operating temperature. Spacecraft orienting and aiming will be performed by four electrically powered reaction wheels. Liquid fuel will not be required for the attitude control. Toward the end of the SPIRIT III sensor's lifetime (approximately two years), contamination and mirror cleaning experiments will be conducted on the spacecraft; there will be no chemical releases from these experiments. The other experiments do not have limited lifetimes, however, the MSX program will likely stop operating the satellite after five years.

JHU/APL will be the command and telemetry connection for the satellite once it is in orbit and requires a Mission Control Center (MCC) and Mission Processing Center (MPC). Data from the experiments will be recorded onboard and downlinked to JHU/APL and other existing earth stations. Radio transmission to the spacecraft and data transmission to the ground stations will not cause ground impacts, due to the beam fluctuation with distance. No laser communication devices will be used. These on-orbit activities will be coordinated with CSTC at Onizuka AFB, California.

The spacecraft will remain on-orbit for several hundred years. Program plans for MSX do not require deorbit capability or deorbit plans, which is consistent with WSMC 127-1. CSTC will track MSX and identify when orbit degeneration will occur. All expendables such as cryogens are expected to be consumed by the end of the MSX mission, and only the small quantity of radioactive material (Ni^{63}) will be aboard and deorbit (PRA, 1992).

2.1.8 Spacecraft Control and Data Management Activities

The MCC at JHU/APL will be the command and telemetry connection for the satellite once it is in orbit. The Phillips Laboratory Geophysics Directorate (PL/GD), the MSX Data Manager, will be responsible for the design, development, implementation, and execution of the data management system (PRA, 1990b). PL/GD activities will extend from receiving raw telemetry data from the spacecraft to distributing system-related data products to the scientists and other users (SDIO, 1990a). Initial processing of data will be done at the JHU/APL MPC. The data will then be sent to the SDIO Backgrounds Data Center at Naval Research Laboratory (NRL) in Washington, D.C. The processed information will also be sent to the Data Processing Centers at USU/SDL, JHU/APL, MIT/LL, and PL/GD (PRA, 1990b).

2.1.9 Dedicated Targets

Target payloads for the MSX sensors will be launched on dedicated suborbital boosters such as the Strategic Target System (STARS) and Minuteman I (MMI) (see Table 2-2) (PRA, 1991). Only boosters with completed environmental documentation will be used. Specific targets may

TABLE 2-2
MSX DEDICATED TARGETS SUMMARY

VEHICLE	DATA OBJECTIVE	LAUNCH/IMPACT
STARS/ODES	PBV deployment phenomenology, in darkness	KTF to USAKA
STARS/c.f.e	Fuel vent signature in outer atmosphere	KTF to USAKA
STARS/ODES	PBV deployment phenomenology, across terminator	KTF to USAKA
Minuteman I/c.f.e	RV re-entry phenomenology, in sunlight	VAFB to USAKA

c.f.e. = a "consolidated front end," a simple top-stage without the sophisticated capabilities of a true PBV like ODES

include any of the following: aeroshells, lightweight replicas, instrumented balloons, emissive and reflective reference spheres, chaff, debris fragments, and unsymmetrical dimethyl hydrazine (UDMH) fuel. Two of the dedicated target payloads will consist of Operational and Deployment Experiments Simulator (ODES) configuration payloads and one will be a fuel vent experiment payload. These three payloads are planned to be launched on three-stage STARS boosters from the Kauai Test Facility (KTF). A fourth target will be an experiment of reentry phenomenology, and is planned to be launched on a MMI booster from Vandenberg AFB. Minuteman Launch Facilities on North Vandenberg are shown on Figure 2-4. Flights that utilize the ODES payload as currently configured must use the STARS booster. Some target payloads may use either STARS or MMI. All targets will impact in the broad ocean area (BOA) off U.S. Army Kwajalein Atoll (USAKA).

STARS launches from the KTF were assessed in *Environmental Assessment - Strategic Target System (STARS)* (USASDC, 1990a) and its supplement (USASDC, 1991). The U.S. Army Strategic Defense Command (USASDC) has also, in response to strong public interest, initiated work on an environmental impact statement (EIS) for the STARS program. The STARS EA found potentially significant, but mitigable, environmental impacts to archeological resources from construction activities; to the Newell's shearwater, a federally listed threatened bird species, from the use of unshielded floodlights; to biological resources and human safety from the use of liquid propellants; and to vegetation from the high exhaust temperatures associated with the STARS launch. No potential for significant impacts was found to other environmental media. Impacts of spent components and debris will occur in the broad ocean area between KTF and USAKA. Use of ODES targets on the STARS was also the subject of *Record of Environmental Consideration (REC), Operational and Deployment Experiments Simulator (ODES)* (USASDC, 1990b). Launch profiles and target characteristics for dedicated MSX launches were compared to, and found to be consistent with, those assessed in the STARS EA and supplement and the ODES REC; no significant impacts would be expected to result from use of STARS and ODES for MSX.

Launch, flight tracking, and other range control operations for MMI missiles from Vandenberg AFB are part of the ongoing operations at Vandenberg AFB using existing facilities, and are assessed in *Environmental Assessment for Minuteman and Thor Missile Launches at Vandenberg AFB, California* (USAF, 1976). No construction or other ground-disturbing activities will be required for MMI launches for MSX. Impacts resulting from spent components and debris will occur in the broad ocean area between Vandenberg AFB and USAKA. The referenced analyses concluded that no impacts would result to cultural resources, infrastructure, socioeconomic, hazardous waste, or water quality from MMI flight activities. MMI flights have the potential to impact air quality, biological resources, land use, noise and public health and safety; however, no significant individual or cumulative impacts were found. MMI launches and target payloads for MSX are comparable to those assessed in the referenced EA and routinely experienced at Vandenberg AFB; no significant impacts from MSX would be expected to result from the use of MMI missiles.

2.1.10 Non-Dedicated Targets

In addition to the dedicated targets discussed above, the MSX program will involve several cooperative targets and various targets of opportunity. While these targets are not driven by or attributable to MSX, a description of their relationship to MSX is included for completeness.

A cooperative target program that will be used by MSX to measure signature data is the Exoatmospheric Discrimination Experiment (EDX) (USASDC, 1990c). MSX will view four EDX flights launched on MMI missiles that will deploy a variety of RVs and penaids. Penetration aids (penaids) are devices such as chaff and decoys that accompany a RV to misdirect defenses to allow the RV to reach its target. Each EDX booster and sensor payload is to be launched from KTF, and a target complex will be released from a MMI missile launched from Vandenberg AFB, California. For these joint MSX/EDX encounters, EDX will be the primary source of high-quality LWIR target signature data, while the MSX will provide functional demonstration of midcourse sensor acquisition, tracking and discrimination. MSX will also provide additional target signature data in the LWIR, visible, and ultraviolet spectra.

Targets of opportunity will be viewed by MSX as circumstances permit. These are expected to include other programs with target launches, as well as other events of interest, and could include other SDIO experiment programs, Air Force Air Combat Command Intercontinental Ballistic Missile (ICBM) tests, Navy Sea Launched Ballistic Missile (SLBM) tests, NASA experiments, Shuttle launches and payload deployments, other Eastern Range (ER) and Western Range (WR) launches, and commercial launches.

MSX interaction with cooperative targets and targets of opportunity will include coordination of launch and event times, communications, and data transmission, and will be conducted as a part of normal program operations (JHU/APL, 1990). No potentially significant impacts will be induced by either the MSX satellite operations or the response of the nondedicated targets.

2.1.11 Ancillary Sensors

In addition to the target and spacecraft instrumentation, several ancillary sensors will be utilized on a mission-by-mission basis for obtaining corollary measurements to aid in post-mission analyses. These sensors include, but are not limited to: AMOS, KREMS, AOA/AST, ARGUS, OAMP, HALO/IRIS, SUPER RADOT, PL/GD KC-135, and DARPA Music AIRCRAFT. Activities by these ancillary sensors will be conducted as part of their normal program operation.

2.1.12 Construction

JHU/APL, as the planning and operations ground control site, will control the telemetry interaction with the satellite once it is in orbit. The JHU/APL facility was upgraded to include a 10-meter parabolic dish antenna and antenna support structure. The purpose of the antenna is to provide a space/ground link system for the MSX program. The MSX program requires that the antenna collect data during a high percentage of each pass of the polar orbit. Therefore, the antenna was elevated to provide horizon-to-horizon coverage unobstructed by JHU/APL

buildings. The antenna and support structure are located inside a security perimeter fence, immediately adjacent to building 23 (see Figure 2-6). The structure is 43 feet high (approximately 4 stories), and has a 40-foot square base, and is open-framed with no side covering (see Figure 2-7).

Scientific Atlanta was contracted to install the antenna with pedestal and an equipment shelter. Electrical power is supplied to the antenna pedestal from a commercial power source located adjacent to the JHU/APL road system on the other side of Building 23. Power will be ensured by an uninterruptible power supply located in Building 36 that houses the MCC/MPC. Other signal cables connecting transmitting and receiving equipment located in the MCC/MPC are in a protective conduit buried in a trench between Building 36 and the antenna support structure. Trenching depth for a water utility line averages 3.5 feet under existing grade. Trenching depth for the other types of conduit averages 2 to 3 feet under existing grade. A Categorical Exclusion for the construction and operation of this antenna at JHU/APL was completed by SDIO in January 1992.

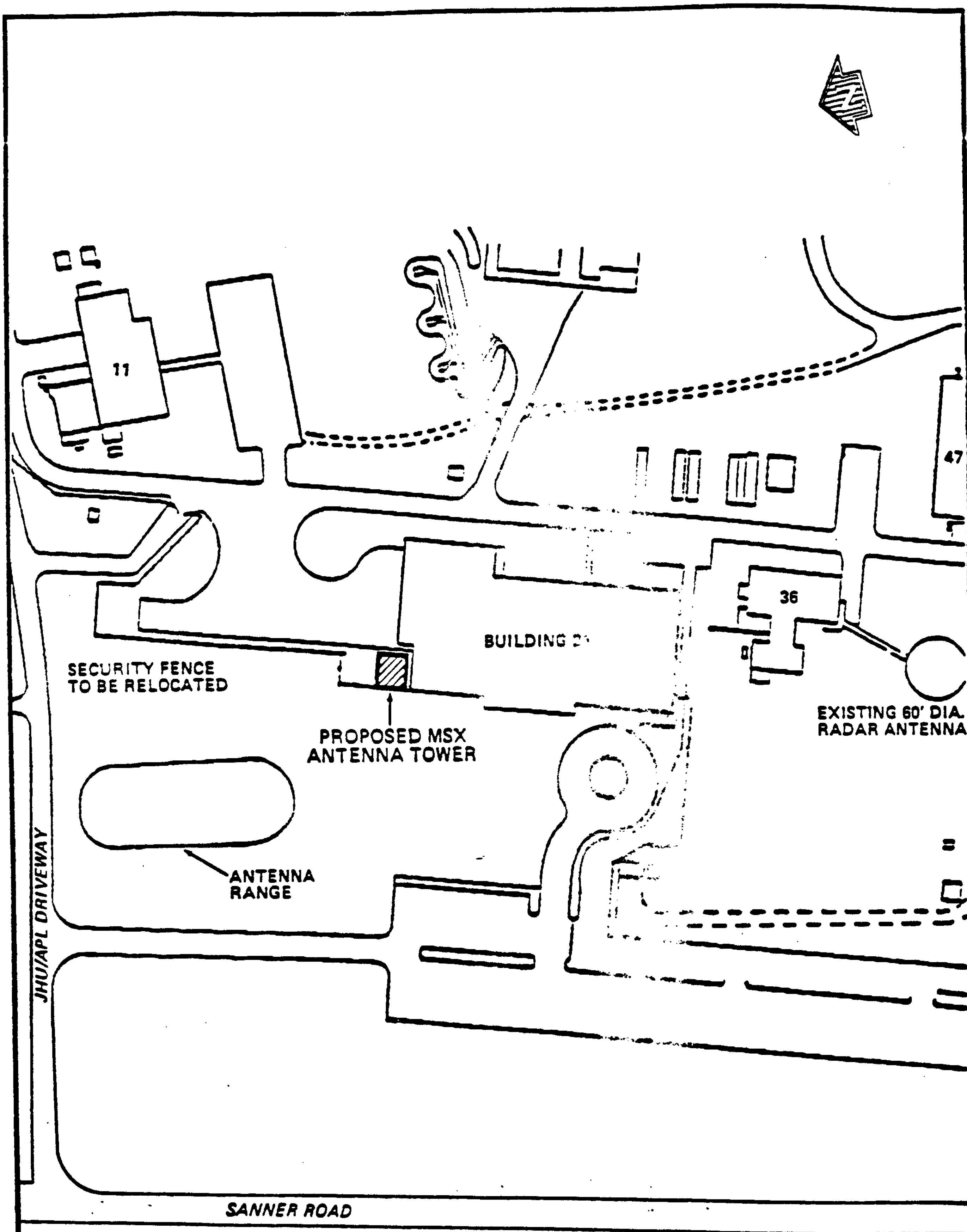
2.2 No Action Alternative

The no action alternative is to not conduct the MSX program and to continue the development of midcourse sensors without the ability of the MSX spacecraft to gather actual flight test data. Mission requirements for midcourse sensors development as described in Section 1 would not be met.

2.3 Alternatives Considered But Not Carried Forward

2.3.1 Alternative Launch Locations

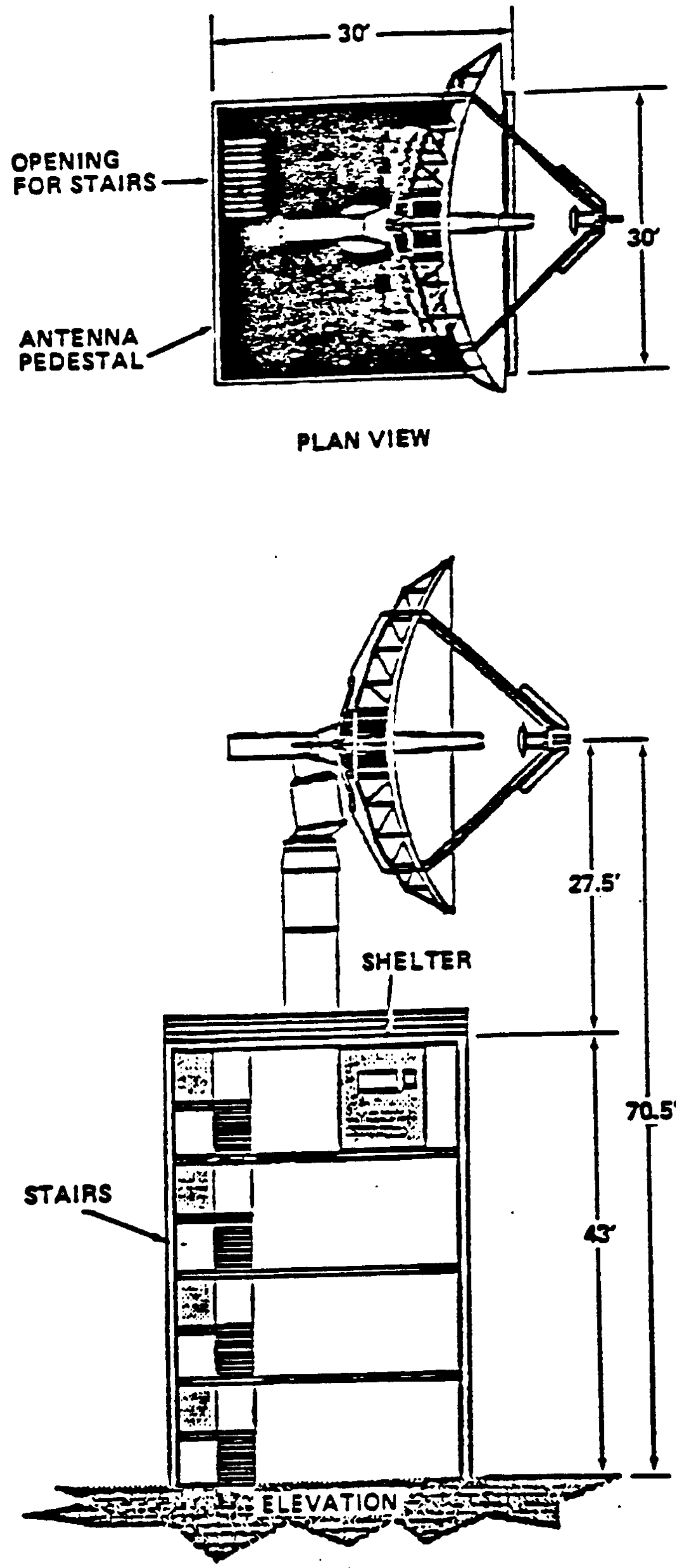
The only alternative space center and range in the United States with capabilities to support medium launch vehicles such as the Delta II is Cape Canaveral Air Force Station (CCAFS), Florida. Cape Canaveral has existing facilities to support Delta II; however, it is limited to easterly launch azimuths in order to avoid land overflight (see Figure 2-5). In-flight change to a polar orbit after a CCAFS launch, while technically feasible, would increase the amount of fuel burned, decrease the payload capacity, and increase safety hazards (DOT, 1988). For MSX, the extra fuel expenditure would reduce the maximum orbital altitude to below mission requirements (PRA, 1991b). Vandenberg AFB is the only location with the capability to deliver payloads directly into polar orbit. MSX mission parameters call for a polar orbit in order to observe atmospheric phenomena at various earth latitudes (PRA, 1991b). Vandenberg AFB is located on a headland, extending into the Pacific Ocean; therefore, launches that have southerly launch azimuths (i.e., launches into a polar orbit) do not pass over any major land mass while the booster is low enough to pose a potential ground safety threat. Also, the Space Shuttle was eliminated because it does not launch into polar orbit from CCAFS.



SOURCE: THG. 1991

FIGURE 2-6
JHU/APL SITE MAP

NOT TO SCALE



SOURCE: JHU/AFL

NOT TO SCALE
Note: Dimensions in feet.

FIGURE 2-7
ELEVATION OF MSX RADAR ANTENNA

2.3.2 Alternative Launch Vehicles

Launch vehicles of an appropriate size and having other performance characteristics to boost the nearly 6,000 pound MSX spacecraft into orbit are limited in number, and consist of variants of Delta, Atlas, and Titan rockets: the augmented Titan II, made by Martin Marietta; the Atlas-Centaur, made by General Dynamics; and the Delta II, made by McDonnell Douglas. Small performance differences (predicted performance, in the case of the augmented Titan II) separate these three, but any one would satisfy MSX requirements (PRA, 1991b). Environmental impact differences (air emissions, noise) between the three are also small (PRA, 1992).

The Delta II launch vehicle was chosen over alternative vehicles on the basis of thrust and other performance characteristics, commercial availability, and cost in a competitive procurement. General Dynamics did not submit a proposal in response to the MSX launch vehicle solicitation, thus eliminating the Atlas from consideration. Reliability uncertainties weighed against the Titan II, as the augmented Titan II has not proven itself in a real launch; MSX would be its first. The Delta II has proven its reliability in numerous previous launches (PRA, 1991b; PRA, 1992).

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Affected Environment 3.0

3.0 Affected Environment

This section provides a discussion of the environment at locations that will be affected by the proposed action. These locations include those for fabrication, assembly, integration testing, and prelaunch and launch activities for the MSX spacecraft.

Information regarding MSX activity locations was obtained from a site visit to JHU/APL, background questionnaires, telephone interviews, and extracts from existing environmental documentation. The goal was to identify current and proposed activities and the status of environmental compliance at the various facilities. Activities at each facility were reviewed to determine the potential impacts from execution of the proposed activities on the existing characteristics in the following environmental media: physical setting and land use, geology and water resources, air quality, noise, biological resources, threatened and endangered species, cultural resources, aesthetics, infrastructure, hazardous materials and waste, and safety. The description here of the existing environment at each facility is consistent with the level of activity proposed and the potential effect on the environment.

The baseline information on the locations and test activities provides a basis for assessing the significance of potential impacts. Many of the environmental media are regulated by Federal and/or state regulations, which also helped determine the level of significance of impacts.

3.1 Fabrication, Assembly, and Integration Testing Locations

3.1.1 Massachusetts Institute of Technology/Lincoln Laboratory, Lexington, Massachusetts

Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL) was established in 1951 under DOD sponsorship. Lincoln Laboratory is a federally funded Research and Development Center operated by MIT. Its purpose is to perform, analyze, integrate, support, and manage basic and applied research and development in support of National Defense. MIT/LL is located on Hanscom AFB in Lexington, Massachusetts. It employs more than 900 technical staff members (MIT/LL, undated).

Activities to be performed for MSX at MIT/LL (e.g., SBV sensor and reference objects development) are routine procedures and take place within the existing facilities. No construction or additional personnel will be required for MSX-related activities. Lincoln Laboratory is in compliance with environmental requirements and has all required permits. The activities planned for MSX fit within the scope of existing safety plans (MIT/LL, 1991a; MIT/LL, 1991b).

3.1.2 Utah State University/Space Dynamics Laboratory, Logan, Utah

Utah State University/Space Dynamics Laboratory (USU/SDL) has played a key research role in the U.S. Space Program since 1959, and today conducts experimentation and instrumentation for upper atmospheric and space measurements. USU/SDL has instrumented and performed

measurements for atmospheric research with sounding rockets, aircraft, and satellites including instrumentation for space shuttle flights and rocketry payloads (USU/SDL, 1991a). Located in Logan Utah, SDL, under the auspices of USU, has a total of 263 employees (USU/SDL, 1991a).

Activities to be performed for MSX at USU/SDL are routine procedures and take place within existing facilities. No construction or additional personnel will be required for MSX activities. USU/SDL is in compliance with environmental requirements and has all required permits. Also, safety plans currently exist for activities planned for MSX (USU/SDL, 1991b).

3.1.3 Johns Hopkins University/Applied Physics Laboratory, Laurel, Maryland

JHU/APL was formed in 1942 and is located in southeastern Howard County. The site is approximately 22 miles from the center of Washington, D.C, halfway between Baltimore and Washington, D.C. JHU/APL has a campus-like setting on 360 acres with over 100 specialty laboratories and other facilities, and numerous radar antennae. JHU/APL currently employs approximately 2,800 people.

The MSX spacecraft will be developed in Buildings 23 and 36, located on the northwest section of the JHU/APL property. The antenna site is immediately next to Building 23 (see Figure 2-6). The site is a flat, grassed area originally graded in 1983 at the time of Building 23 construction. On the north and east sides of the site are laboratory and maintenance buildings. Building 36 and a 60-foot diameter radar antenna are located on the south side of the site. To the west of the site is an antenna range used for calibrating antennas, an interior road, and a parking lot area. Development next to the northwest area of JHU/APL is characterized by large, developed 3-acre lots in a rural residential zone. According to the Howard County General Plan (Howard County, 1991), this area will remain residential at its current density.

Activities to be performed for MSX at JHU/APL are routine procedures and take place within existing facilities. No additional personnel will be required for MSX activities, and safety plans currently exist for activities planned for MSX.

3.2 MSX Spacecraft Prelaunch and Launch Location, Vandenberg Air Force Base, California

The prelaunch and launch activities for the MSX satellite will be located at SLC-2W at Vandenberg AFB. SLC-2W will be modified so that both Delta I and Delta II configuration rockets can be launched from Vandenberg AFB. NASA has prepared an environmental assessment, dated September 1991, for the modification and subsequent operation of SLC-2W. The SLC-2W EA discusses the existing environment and significant issues in detail, and has been incorporated in this document by reference. This section summarizes the affected environment section of that document relevant to the preparation of the MSX spacecraft.

Vandenberg AFB occupies 98,400 acres (154 square miles) along the south central coast of California, 140 miles northwest of Los Angeles and about 5 miles west of Lompoc in Santa Barbara County. Vandenberg AFB is bounded by the Pacific Ocean to the west and south. Areas adjoining the north and east boundaries of Vandenberg AFB are used mainly for grazing

and intensive agriculture. Offshore uses to the west are mostly oil production and marine activities. Portions of the land on the base are used for agriculture, grazing, hunting, and fishing.

The surface topography of Vandenberg AFB is varied. The highest topographic relief is in the northern and southern parts of the base. The central portion consists of a large mesa, the Burton Mesa. SLC-2W is on the Burton Mesa, between two watercourses, about one mile from the ocean shore near Purisima Point. Sand dunes extend inland from the ocean to the proximity of SLC-2W.

Groundwater in the Vandenberg AFB vicinity is present in four groundwater basins, and groundwater is the sole source of potable water on Vandenberg AFB for approximately 3,401 acre-feet per year of domestic and operational use. Increased withdrawals from the area's ground water basins for Vandenberg AFB, municipal, and agricultural use have created an overdraft condition that is affecting the availability and quality of water in these basins.

Water quality of surface water near SLC-2W is recognized as poor to medium quality due to the high levels of total dissolved solids, chloride, lead, and zinc. However, ground water quality in the region meets all National Interim Primary Drinking Water Regulations. Inorganic, organic, pesticide, and herbicide constituents parameters are monitored for each of Vandenberg AFB's ground water wells.

Vandenberg AFB is part of the California South Central Coast Basin. Historically recorded data from State and Local Air Monitoring Stations (SLAMS) provided the most accurate air quality data for the SLC-2W launch site area. Up to May 1988, the SLAMS recorded levels of ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), particulate matter (less than 10 microns in size) (PM_{10}) and total suspended particulate (TSP). In April 1992, the Watt Road Prevention of Significant Deterioration (PSD) site will begin 12 months of preconstruction monitoring for pollutants. The Watt Road station will become the second PSD site located on Vandenberg AFB (USAF, 1992). These data are published quarterly and summarized annually. In October 1987, the Santa Barbara County Air Pollution Control District (SBCAPCD) suggested that North Santa Barbara County be redesignated as a nonattainment area for ozone because national ambient air quality standards (NAAQS) were exceeded. Also, the SBCAPCD considers the area in nonattainment of State particulate matter standards and regulates this pollutant and its precursor, sulfur oxides (SO_x).

The SLC-2W facility is relatively isolated from civilian residential areas. Ambient noise levels at Vandenberg AFB are generally low. The primary sources of noise at Vandenberg AFB are from the following: aircraft takeoffs and landings, rocket launches, railroad traffic, and automobile and truck traffic.

Vegetation within the boundaries of the SLC-2W facility is very sparse and is characteristic of a coastal dune scrub community. This community is dominated by a dense cover of shrubs 3 to 7 feet high. Native shrubs include mock heather, dune lupine, California sage brush, deerweed, and dune mint. Vegetation within the facility boundary is very sparse. Introduced species, such as ice plant, mission veldt grass, and pampas grass, are dominant in areas not covered by structures or paving.

Herbaceous vegetation of concern known to occur in the coastal dune habitat include: dune mint, soft leaved indian paint brush, LaGraciosa thistle, surf thistle, and coast spectacle pod. The dune mint, soft leaved indian paint brush, and coast spectacle pod are Federal Category 2 species. The LaGraciosa thistle is a threatened Federal Category species, and surf thistle is listed by California as threatened. The surf thistle and coast spectacle pod are known to occur within the SLC-2W area.

In the vicinity of SLC-2W, wildlife is sparse due to the long history of disturbance, the lack of cover, and the absence of fresh water, as well as the current presence of humans and facilities. The western fence lizard and the western gull have been observed within the project area. However, the western fence lizard is rather widespread, and the Western gull may be found in any coastal area of California.

Four federally listed endangered or threatened wildlife species known to occur on Vandenberg AFB include the Unarmored Threespine Stickleback, the California Brown Pelican, the California Least Tern, and the California Sea Otter. The Western Snowy Plover, a Federal Category 1 Species, is also known to frequent the area. The Honda, San Antonio Creeks, the mouth of the Santa Ynez River, the dunes at Purisima Point, and Vandenberg AFB coastline provide habitat for these species. Only the California Least Tern was at issue for impacts from the launch of the Delta II in the SLC-2W EA.

The California Least Tern has been known to nest at Purisima Point (approximately 2,200 feet form SLC-2W) from approximately April through August. A monitoring program in effect since 1980 has observed a high of 30 nesting pairs in 1980 and a low of zero nesting pairs in 1986. The program counted 14 breeding pairs in 1987 and 9 pairs in 1990.

The area is rich in prehistoric, historic, and cultural resources, and there are cultural resources in the immediate vicinity of SLC-2W. A cultural resources identification survey is being conducted in accordance with Section 106 of the National Historic Preservation Act. Limiting access to the area also contributes to the preservation of known and unknown prehistoric, historic, and cultural resources.

Vandenberg AFB's economic impact region consists of the area generally within a 50-mile radius of the Base and includes most of Santa Barbara and San Luis Obispo Counties. Vandenberg AFB is a major economic force, estimated to provide about two-thirds of the local job opportunities. Employment at Vandenberg AFB, however, has decreased from approximately 16,000 in 1985 to about 11,000 at the present time.

Energy for the Vandenberg AFB region is supplied by electric power from the Pacific Gas and Electric Company. Government electric energy generating capacity is controlled by the U.S. Air Force and additional power is available from commercial sources.

Propellants are routinely recycled from overflow lines and waste propellant is typically not generated by SLC-2W launches. In order to reduce hazardous waste during Delta II fueling, deionized water rather than freon will be used to flush the nitrogen tetroxide (N_2O_4) system. The aerozine-50 system uses a scrubber water catch tank, rather than an open pond. Deluge water

is captured in a newly-sealed collection pond. In addition, the water flow on the deluge system was recently adjusted to reduce the amount of wastewater produced from 21,000 gallons of water to 7,000 gallons of water (with no reduction of flow during the critical engine ignition period).

With respect to all activities related to rocket launches and fuel handling and storage, Vandenberg AFB complies with the military System Safety Program Plan, which assures compliance with Federal, state, and Air Force Occupational Safety zones and explosives. A safety review will be conducted for each program (including MSX) and documented in an Accident Risk Assessment Report. This report will assess the launch vehicle, the payload, support equipment, and facilities. A range safety certification must be completed six months before the launch.

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Environmental Consequences 4.0

4.0 Environmental Consequences

The significance of potential impacts that may result from MSX activities to each of the environmental media was assessed by analyzing the description of the proposed action and alternatives (DOPAA) (Section 2.0) with respect to the environmental setting at each participating installation (Section 3.0). Environmental media evaluated include: physical setting and land use, geology and water resources, air quality, noise, biological resources, threatened and endangered species, cultural resources, infrastructure, hazardous materials and waste, and public health and safety.

Each phase of the MSX program was examined to determine whether the potential existed for environmental impact. These phases were then evaluated in terms of each site and medium to determine if: 1) an impact could potentially occur, and 2) if the impact would be significant. The criteria for assessing impact significance vary according to the medium under consideration. Specific Federal or state standards are applicable to certain media; those standards provide the measure of "significance." For those media in which standards are not applicable, impacts were measured against the percentage reduction in availability of the resource (for either humans or flora and fauna) against the overall resource availability. Where a potentially significant impact has been identified, appropriate mitigation measures will be adopted to eliminate or reduce impacts to nonsignificant levels.

Section 4.1 of this EA describes the environmental consequences of the fabrication, assembly, and integration testing at MIT/LL, USU/SDL, and JHU/APL. Section 4.2 describes the environmental impacts at the MSX satellite prelaunch and launch location, Vandenberg AFB. MSX satellite operations in space are discussed in Section 4.3. Section 4.4 describes potential cumulative impacts. Impacts from the no action alternative are described in Section 4.5.

4.1 Fabrication, Assembly, and Integration Testing Locations

The purpose of this section is to determine whether the MSX activities will cause significant (adverse or beneficial) impact to the existing environment at specific geographic locations. Only unique environmental issues from MSX-specific activities at fabrication, assembly, and integration testing locations are additions to the existing baseline at the locations are discussed.

4.1.1 Massachusetts Institute of Technology/Lincoln Laboratory, Lexington, Massachusetts

MIT/LL is responsible for providing the SBV sensor and Reference Objects. These activities are within the normal scope of operations routinely conducted at MIT/LL. The activities will take place at existing facilities. No additional personnel or facilities will be required. No significant project-specific or cumulative environmental impacts are expected as a result of MSX activities at MIT/LL.

4.1.2 Utah State University/Space Dynamics Laboratory, Logan, Utah

USU/SDL is responsible for developing and fabricating the SPIRIT III sensor and ground support and calibration equipment. These activities are within the normal scope of operations routinely conducted at USU/SDL. The activities will take place in existing facilities and no construction is anticipated. Although additional personnel will be hired, the number will be fewer than ten. No significant project-specific or cumulative environmental impacts are expected as a result of MSX activities at USU/SDL.

4.1.3 Johns Hopkins University/Applied Physics Laboratory, Laurel, Maryland

JHU/APL is responsible for the following activities: satellite support instrumentation development; UVISI sensor development; the contamination experiment development; and satellite systems integration and testing. These activities fit within the scope of the activities routinely conducted at JHU/APL. No additional personnel will be necessary.

The satellite communications facility at JHU/APL was upgraded to include a 10-meter parabolic antenna and antenna support structure. A small area was trenched for utility lines and a 40-foot by 40-foot area was developed for a concrete pad to support the radar tower. The antenna support structure site and the cable trench areas are flat, grassed areas originally graded at the time of the construction of Building 23 (see Figure 2-6 for JHU/APL site map). A categorical exclusion for the construction and operation of this antenna at JHU/APL was completed by SDIO in January 1992.

4.2 MSX Spacecraft Prelaunch and Launch Location, Vandenberg Air Force Base, California

The Environmental Assessment for the Modification of Space Launch Complex-2W (NASA, 1991a) is incorporated in this document by reference in accordance with Council on Environmental Quality regulations (40 CFR 1502.21). All MSX program activities related to the assembly and launch of the Delta II rocket will operate within the SLC-2W FONSI and conform to the mitigation measures contained therein.

This section discusses issues unique to the MSX spacecraft and addresses any potential impacts and required mitigation specific to the MSX program. A brief review of the critical issues identified in the SLC-2W EA is also provided for completeness. Unless otherwise noted, discussion regarding impacts from the Delta II launch are from the SLC-2W EA.

Potential environmental effects on water quality from the launch of a Delta II include: contamination of geology and water resources from deluge water; launch pad accidents and propellant spills; contamination of surface waters from exhaust-cloud deposition of HCl and Al_2O_3; and flight failure that may result in propellants falling into the ocean or nearby surface waters. The deluge, fire suppressant, and/or postlaunch washdown water will be collected in a sealed catchment basins. The water will be analyzed to determine how it will be discharged; i.e., to grade, to the base treatment plant, or to a hazardous waste facility. Accidental releases of small

quantities of fuel and propellants may occur at the launch pad. Such spills, however, are designed to be retained in the impervious holding areas surrounding the fuel and propellant supply tanks. HCl deposited in surrounding surface waters as a result of the launch of the Delta II rocket and its subsequent ground cloud will not generate significant long-term impacts based on the low frequency of launch events, expected cloud dissipation and the dissipation of contaminants along the vehicle's flight trajectory. Al_2O_3 deposited in surface waters will remain insoluble and will not be toxic to aquatic life. No significant impacts to ground water or surface water are expected as a result of the MSX Delta II launch. Potential Delta II impacts on water quality are not anticipated to be exacerbated by the MSX spacecraft payload. No liquids are aboard the spacecraft, and no releases to surface or ground water will occur from the payload during a normal launch. Contamination from a fire or other launch accident would result mainly from the Delta II booster and not from the MSX payload.

Potential air pollutant emissions at Vandenberg AFB due to the launch of a Delta II spacecraft include: chemical releases during fueling and prelaunch testing and launch emissions during liftoff. The release of fuels during ground operations will be controlled by scrubber systems, roof vents, air handlers, and recovery systems. The only Delta II launch emission that presents an environmental concern at ground level is HCl. This emission will be limited to a small area, will be of short duration, will be confined to restricted areas already historically exposed to HCl, and will not exacerbate existing conditions. Significant impacts to air quality from the prelaunch and launch of a Delta II are not expected.

Vapors from cryogenic liquids (hydrogen & argon) on the MSX spacecraft payload will be released to the atmosphere during prelaunch maintenance. Minor venting of the hydrogen and argon cryogens will also occur during launch. Impacts from these emissions will be minimal, because the emission quantities are very small relative to the amounts of hydrogen and argon that exist naturally in the atmosphere.

The SLC-2W pad and payload processing facilities have permits that control and limit atmospheric releases during operations. These permits were modified slightly to accommodate Delta II launches. The MSX spacecraft operations will not exceed the existing permits for SLC-2W (USAF, 1991).

Noise impacts to the Least Tern, whose breeding grounds are located approximately 2,200 feet from SLC-2W, will not be significant because Delta II launches (including the MSX Delta II launch) will not occur during the breeding season (mid-april to August). In addition, NASA will monitor noise levels at Purisima Point during Delta II launches. Delta II noise levels will be unaffected by the MSX payload.

Potential impacts to the environment due to hazardous materials could occur due to the presence of the liquid Delta II rocket propellants (RP-1 [a type of kerosene], liquid oxygen, Aerozine-50, and nitrogen tetroxide), MSX payload cryogenics, and cleaning solvents used for booster and payload preparation. The MSX payload has no rocket propellants aboard. In the event of a cryogen spill, the liquid hydrogen and argon would quickly gassify, and dissipate into the atmosphere. Other wastes that could be generated during the prelaunch activities for a Delta II vehicle include incidental quantities of: solvents, adhesives, lubricants, fuel, propellant, and

contaminated rags or cotton swabs. MSX payload preparation would generate very minor quantities of hazardous wastes similar to those produced by Delta II preparation activities. All hazardous wastes will be handled by a licensed hazardous waste disposal facility in accordance with the Hazardous Waste Source Reduction and Management Review Act of 1989.

Potential impacts to public health and safety may occur as a result of launching the MSX spacecraft on the Delta II launch vehicle. The assembly and fueling of the Delta II rocket will be conducted in accordance with activity-specific standard operating procedures that will be developed for this launch and will integrate procedures for the rocket and MSX payload. In the event of a spill, clean-up procedures will be conducted in accordance with the emergency contingency plan developed by the USAF 30SPW and the Spill Prevention Control and Countermeasure Plan which integrates base plans for emergency response.

Safety requirements at Vandenberg AFB will ensure that all workers and the public remain outside of established safety zones. Explosive safety quantity distances (ESQDs) will be established around storage areas and the launch pad. The public and any observers of the launch will be outside of the ground hazard area (GHA) established for this launch. Such safety areas are designed to minimize impacts to operations personnel and the public from potentially damaging noise, air emissions, or debris in the event of a failure. Personnel within the safety area will wear personal protective equipment or remain within the launch operations control building. In addition, the closest uncontrolled area (i.e., public area) from SLC-2W is approximately 5.5 miles away. Because the MSX ESQD and GHA will be unchanged from those for the Delta II alone, there would not be a significant impact to the public as a result of the launching of the MSX spacecraft.

Range safety at Vandenberg has the capability to activate the launch vehicle's self-destruct system until the vehicle is even with the northern Mexico latitudes. Advanced notice will be given to ships, oil platforms, and others along the booster's flight path so that personnel may be cleared from these areas during the launch. Airborne observers will follow the flight path immediately following lift-off to verify that the spent booster stages fall into the ocean (i.e. do not impact ships, oil platforms, etc.). Although analysis has not been completed specifically for the MSX launch, previous analyses completed for similar flights have shown that the launch vehicle and spacecraft will land on the Antarctic continent if they fall into a suborbital flight path (PRA, 1991b).

The potential safety hazards from the MSX payload are as follows: the radioactive Ni^{63} isotope carried in the krypton flashlamp; the pyrotechnic separation nuts; and the hydrogen-filled cryostat (PRA, 1991b). The amount of Ni^{63} isotope required for the krypton flashlamp will not be harmful to personnel (JHU/APL, 1991a). The level of radiation that will be emitted is expected to be 80 microcuries (μCi). Because this level is below the threshold of 100 μCi, licensing and stringent control procedures and documentation will not be required. In addition, standard operating procedures will be developed in a Safety Analysis Summary and implemented by JHU/APL. No significant impacts to public health and safety will occur as a result of the Ni^{63} in the flashlamp.

Pyrotechnic separation nuts with a small amount of explosive material will be used to separate the spacecraft from the launch vehicle. The hazard they present is the danger of exploding during the prelaunch and launch activities. Standard safety operating procedures concerning the use of the separation nuts will be developed and implemented prior to any payload processing activities or launch operations. No significant impacts to public health and safety will occur as a result of the separation nuts.

The hydrogen-filled dewar for the SPIRIT III sensor will contain 172 pounds of solid (i.e. frozen) hydrogen. Hydrogen gas is an explosive substance and asphyxiant. If the temperature of the hydrogen were to rise it would cause the solid hydrogen to move quickly through the liquid phase to become a gas. A large increase in the temperature could cause a rapid expansion of the hydrogen molecules and result in an explosion. This would occur only in the event of a major accident in which the dewar is damaged. Implementation of the MSX system safety program minimizes both the potential for such an occurrence and the risk to personnel should it occur. For safety purposes, to prevent accumulation of hydrogen gas, chemical sensors tuned to detect hydrogen gas will be placed in key locations at the PPF (Building 1610). In the event of a hydrogen leak, the chemical sensors would detect it, alert the workers, and vent it to the atmosphere without harm to the workers or the environment. Release of hydrogen to the atmosphere, either through venting or in the event of a leak or accident, will not result in a significant impact as hydrogen is a component of the atmosphere and will readily diffuse and equilibriate. Significant impacts due to the use of hydrogen cryogen are not anticipated.

4.3 MSX Spacecraft Operations

4.3.1 Spacecraft Operation

The MSX spacecraft will impact the natural space environment in which it operates, and it has the potential to interfere with other satellites or to have impacts on the ground in the United States. In the space environment, venting of 172 pounds of hydrogen from the SPIRIT III dewar and 15 liters of argon from the SPIRIT III lens cover dewar over the approximately two-year lifetime of SPIRIT III will occur in a near-uniform distribution over the earth at the MSX orbit altitude of 888 km. These releases will result in a broad distribution of the gases at very low concentrations.

The releases will occur in the ionosphere, which is a weak, neutral plasma comprised of positive and negative ions, in layers of varying ion density. The ionosphere results from short-wave ultraviolet radiation impinging on the outer atmosphere. That radiation dissociates and ionizes atmospheric oxygen and nitrogen creating an ionic region. Both hydrogen and argon are atmospheric trace gases, and atomic hydrogen is a predominate atmospheric constituent at the release altitude.

At altitudes greater than 200 km, the weak ionospheric plasma is sensitive to neutral molecular concentrations. Chemical releases at these altitudes can cause local depletion of ionospheric plasma, and such depletion can occur within minutes of a release. Introduction of hydrogen at altitudes greater than 200 km may cause chemical transformations to molecular ions at rates 100 to 1,000 times greater than those occurring naturally between nitrogen and oxygen. Under these

conditions, the oxygen ions transfer their charge to the released products reducing ion concentrations.

Horizontal diffusion through the ionosphere will cause rapid dispersion resulting in concentrations that are too low to be of chemical importance in areas remote from the source. Also, in the outer region of the ionosphere, where the release will occur, vertical diffusion results in a rapid escape of molecules before a reaction can occur.

Fluctuations in electron density of 5 to 10 percent have been observed following several space launches, and during these disturbances, multiple reflections of high-frequency radio waves occurred. However, based on the findings of the NASA studies for the larger scale and longer planned duration of the Space Station Freedom (NASA, 1991b), radio communications should not be significantly affected, and no large scale or long duration impacts to the ionosphere are anticipated from the short duration orbits of research program test objects such as MSX.

On-orbit releases will also have no impact on the ozone layer (the majority of which is located in the stratosphere between 10 and 50 kilometer altitudes) since these chemicals are not significant ozone-depleting compounds and diffusion will disperse the releases before an impact could occur within the lower atmosphere. No significant impacts will occur from these releases.

Potential interference with other satellites is possible whenever an object is placed into orbit. Interference would most likely occur as a collision, however; the probability is remote, as explained below. Although the Low Earth Orbit (LEO) region contains the largest spatial density (number/cubic kilometer) of space objects (which includes orbital debris), the probability of collision with other objects would be small. Only a very small percentage of these objects are active satellites. The majority of collision risk is with smaller orbital debris (objects in the order of 10-centimeter cross section). Collision times between LEO debris and a satellite of 5-square-meter cross section on an orbit comparable to MSX is estimated to be in the order of once in every 480,000 years (USDOT, 1988). In addition, orbits utilized by existing satellites are currently monitored and would, therefore, be avoided by MSX. The potential for electromagnetic interference with other satellites is also insignificant. The MSX satellite will use assigned radio frequencies, thereby minimizing possible electromagnetic interference.

On-orbit operation of the SPIRIT III mirror cleaner will not have significant impacts on other spacecraft or sensors or at the earth's surface (USU/SDL, 1992). The focus assembly for the laser to be used for mirror cleaning employs a negative lens; laser radiation will diverge at the output of the lens, and output intensity will dissipate rapidly to insignificant levels within a short distance from the spacecraft. For example, average output density at the 1-centimeter diameter aperture of the 285 mJ laser will be 0.726 watts per square centimeter (W/cm^2), and instantaneous peak intensity will be 9.07×10^4 W/cm^2. By 1 kilometer from the spacecraft, the beam diameter will diverge to 112 meters, and intensity of the beam will decrease by a factor of over 100,000,000. Further dissipation of laser energy will occur between the 888-km orbit of the spacecraft and the earth's surface.

Interactions with the ground that could result in potentially significant impacts are the spacecraft command and control operations and data downlink. These activities will be accomplished using

facilities at JHU/APL, CSTC, and other existing satellite tracking stations, using assigned radio frequencies. These operations are only hazardous near their source due to the fluctuation of the radio beam with distance. In the case of ground stations, sources are monitored and controlled as described in Section 2.1.6. Focused energy beams that can have ground impacts, such as lasers, will not be used for MSX command and control or data transmission.

4.3.2 Target Releases

Target releases from dedicated MSX target flights may include aeroshells, lightweight replicas, instrumented balloons, emissive and reflective reference spheres, chaff, debris fragments, and unburned hydrazine fuel. With the exception of the hydrazine fuel, released objects are expected to have size, weight, and compositions similar to satellites, boosters, and payloads that are routinely placed in suborbital trajectories. The target flight profiles for STARS-launched targets from KTF and MMI-launched targets from Vandenberg AFB have been designed to minimize the risk from land impact of launch debris by using ocean flight trajectories. Deorbiting objects typically break up on reentry, and often vaporize before impacting the earth because of intense aerodynamic heating. Quantities of exotic or toxic materials incorporated in the targets are small, and will be widely dispersed to concentrations within the range of background levels should the vehicle break up and portions vaporize prior to impacting the earth. Impacts from target releases will be not significant because of the negligible likelihood of land impact.

The present proposal for release of 2 canisters approximately 57 pounds each of unburned UDMH fuel at earth altitudes of 300 km and 1,000 km is identical with that assessed in the STARS EA (USASDC, 1990a), where it was found to be not significant. The *Chemical Release Experiment Environmental Assessment* (USAF, 1987) assessed releases of about 100 pounds of hydrazine (several types were assessed, including UDMH) at an earth altitude of 300 km. This report determined the most likely impact to be a localized disturbance (within the near vicinity of the release) to ion concentrations. This disturbance could have an effect on telecommunications or astronomy observations within this limited region; however, these effects are expected to be very transient (on the order of a minute) and not significant. The released fuel would be dispersed (and thus diluted) over the vehicle's flight path and quickly dissipated by the intense ultraviolet radiation and ions present at these altitudes. No significant impacts in space are expected from the MSX fuel vent experiment.

4.3.3 Spacecraft Deorbit

All objects placed in earth orbit have the potential to deorbit and reenter the atmosphere. An estimated 500 objects and thousands of debris fragments reenter each year; however, few survive reentry. Unless specialized protection is provided, most objects will break up and often vaporize under the intense aerodynamic forces and heating that occur during reentry. Roughly 100 of the approximately 3,100 objects resulting from 44 launches between 1956 to 1972 have survived reentry and were recovered (USDOT, 1988). No casualties or injuries are known to have resulted from such surviving fragments, thus, the hazard from reentry debris is considered small (USDOT, 1986).

The MSX spacecraft is not expected to deorbit for 300 to 1,000 years (PRA, 1992). Program plans for MSX and other United States satellites do not include deorbit or orbital transfer plans

or capability. Consolidated Space Test Center (CSTC) deorbit planning does not include satellites with an expected orbital lifetime of greater than 10 years in its current deorbit planning. CSTC currently tracks all satellites in orbit and identifies orbit degeneration. Predictions can then be made as to when and where debris impacts could occur.

Expendables on the MSX spacecraft (cryogens) are expected to be consumed at the end of the MSX mission. Most of the spacecraft is expected to break up and burn up during reentry, which will disseminate any remaining hazardous materials over a wide area. Even if the small amount of low level Ni^{63} radioactive element aboard survived intact, it is insufficient to cause significant health effects (JHU/APL, 1991a).

Fragments of the spacecraft that remain intact have a very low likelihood of causing casualties. Considering that 70 percent of the earth's surface is covered by water and, of the remaining 30 percent of land mass, approximately one quarter is moderately to densely populated, the chances of a populated area being hit upon reentry of space debris is much smaller than the chances of being hit by one of the 500 meteorites that strike the earth each year (OTA, 1990).

4.4 Cumulative Impacts

Ground activities at fabrication, assembly, and integration testing locations are routine operations for each location. Compliance with applicable regulations will ensure that MSX activities will not contribute to cumulative environmental effects at these facilities. The spacecraft prelaunch activities will be conducted in existing facilities and will be within the scope of the activities routinely conducted at those facilities. The Delta II launch for the MSX spacecraft is one of a planned series of launches for which potential cumulative impacts have been addressed and found to be not significant. MSX spacecraft handling and launch activities will not contribute to cumulative environmental effects at Vandenberg AFB. Use of boosters for MSX dedicated target launches that have been assessed programmatically for cumulative impacts will ensure that MSX target launches do not significantly contribute to cumulative environmental effects at launch and range locations.

4.5 Environmental Consequences of the No Action Alternative

The no action alternative is to not conduct the MSX experiment as presently planned. Fabrication, assembly, and integration tests are routine operations with no identifiable impacts at the indicated facilities; it is reasonable to expect that other, similar types of operations would be conducted in the absence of the MSX program with the same lack of impacts.

The MSX satellite launch activities proposed for Vandenberg AFB are similar to ongoing operations at the facility. As detailed in the preceding sections, environmental impacts from the MSX program are low, with no significant impacts. Elimination of the single proposed MSX Delta II launch would result in the booster being reassigned to another program. Therefore, the environmental impacts at Vandenberg AFB from the no action alternative are not expected to differ significantly from those expected to result from the MSX program.

Dedicated target flights on STARS and MMI are using rockets that serve (or are planned to serve) many DOD programs. It is likely that the up to four STARS and MMI rockets planned for use on MSX would be utilized for other programs. Impacts from the no action alternative on target launches are not expected to differ significantly from those identified with the MSX program.

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Agencies and Persons Consulted 5.0

5.0 Agencies and Persons Consulted

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7.0 List of Preparers

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Appendix A - Environmental Background Contact Sheet

Environmental Background Contact Sheet

By ______________________

Date______________________

ORGANIZATION ______________________

POC (Name) ______________________

(Title) ______________________

PHONE ______________

FAX ______________

1. What activities will you perform in support of the MSX Program?

2. Are these activities along the lines of regular activities that you perform in terms of scope and size? Can we assume that you are dealing with proven technology?

3. Where on your facility will testing take place? (area, building #s)

   Is that area particularly degraded or pristine or neither? are the proposed activities expected to be environmentally controversial?

   Have any of the following issues been identified as areas of possible concern?

   - threatened or endangered species?

   - archeological remains or historic sites?

   - prime or unique agricultural land?

   - wetlands?

   - coastal zone?

   - wilderness areas?

- aquifers?

- floodplain?

- wild and scenic rivers?

- superfund sites or other areas of known contamination?

4. Will this undertaking (i.e., fabrication, testing) entail new construction?

5. Will the project require the hiring of additional staff?

6. Please give a brief overview of your time table? (deliverables, major milestones)

7. Whether or not a similar activity has been done in the past, is there any environmental documentation geared towards this project in particular or any similar project which was undertaken in the past by your organization? Also, has any environmental documentation been done as part of your permitting process?

8. If no specific environmental documentation exists (i.e., if #7 is a no), is there some baseline environmental documentation which has been published that you know of which covers similar activities?

9. What are the Federal and state and local environmental permits required to operate the specific facilities that will be employed to perform the proposed activities? Will any new permits from any of the three be required? If yes, what. Is this for construction?

10. If the operations are new to the facility, is there a safety plan proposed? Is it available?

11. What are the transport methods, if any, that are necessary for shipments associated with the proposed activities? Is this routine or not? If not, is there a safety plan/ or what is the safety plan?

12. Will any facilities be decommissioned following the proposed activities?

Environmental Background Contact Sheet

Data Gathering Protocol

The protocol includes a review and analysis of potential environmental effects for each of the primary participants and key test locations in the MSX program. Emphasis is placed on those locations where integration and testing activities that are of a non-routine nature or are specific/unique to SDIO are planned. For planning purposes, the list includes Government laboratories and ranges and primary contractors for components. Should initial contacts disclose potentially significant environmental effects may occur at a particular second-tier contractor, the review/analysis is extended to that contractor.

The process begins with telephone contacts to the points of contact identified, to confirm the roles and relationships involved. Once the initial contact has been made, a list of questions specific to the organization is developed and forwarded to the POC, together with a general questionnaire. The following contact sheet language for labs and contractors that are supporting SDI activities, to be filled out by the POC, in addition to the specific questions.

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Appendix B - Distribution List

Appendix B

MSX Distribution List

Laboratories

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Johns Hopkins Road
Laurel, MD 20707
Attention: Max Peterson

Massachusetts Institute of Technology
Lincoln Laboratory
Space Based Surveillance
Group 92
244 Wood Street
Lexington, MA 02173-9108
Attention: Dr. Joseph C. Chow

Massachusetts Institute of Technology
Lincoln Laboratory
Aerospace Engineering
Group 73
244 Wood Street
Lexington, MA 02173-9108
Attention: Charles Wilson

Utah State University/Space Dynamics Laboratory
1787 N. Research Parkway
Logan, Utah 84321
Attention: Harry O. Aimes

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Washington, DC 20301-7100

SDIO/GC
The Pentagon, Rm. 1E1080
Washington, DC 20301-7100

SDIO/IEA
The Pentagon, Rm. 1E1008
Washington, DC 20301-7100

SDIO/SIS
The Pentagon, Rm. 1E1054
Washington, DC 20301-7100

SDIO Technical Information Center (TIC)
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Arlington, VA 22202

SDIO/TNE
The Pentagon, Rm. 1E180
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SDIO/TNS
The Pentagon, Rm. 1E168
Washington, DC 20301-7100
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USAF/AFSPACECOM/DEPV
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USAF/CEVP
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Attention: John Edwards

USAF/30SPW/XPR
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Plans, Program, Requirements Directorate
Vandenberg AFB, CA 93437-5000
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Attention: Mr. Dru Barrineau

National Aeronautics and Space Administration

National Aeronautics and Space Administration
Facilities Utilization, Maintenence
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National Aeronautics and Space Administration
GSFC-DELTA/OLS West Coast Office
McDonnell Douglas Space Systems Company
MS 12-3, OLS Project
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Other

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Washington Division
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Arlington, VA 22209
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